U. S. COMMISSION OF FISH AND FISHERIES,

GEORGE M. BOWERS, Commissioner.

PART XXIV.

REPORT

OF

THE COMMISSIONER

FOR

THE YEAR ENDING JUNE 30, 1898.

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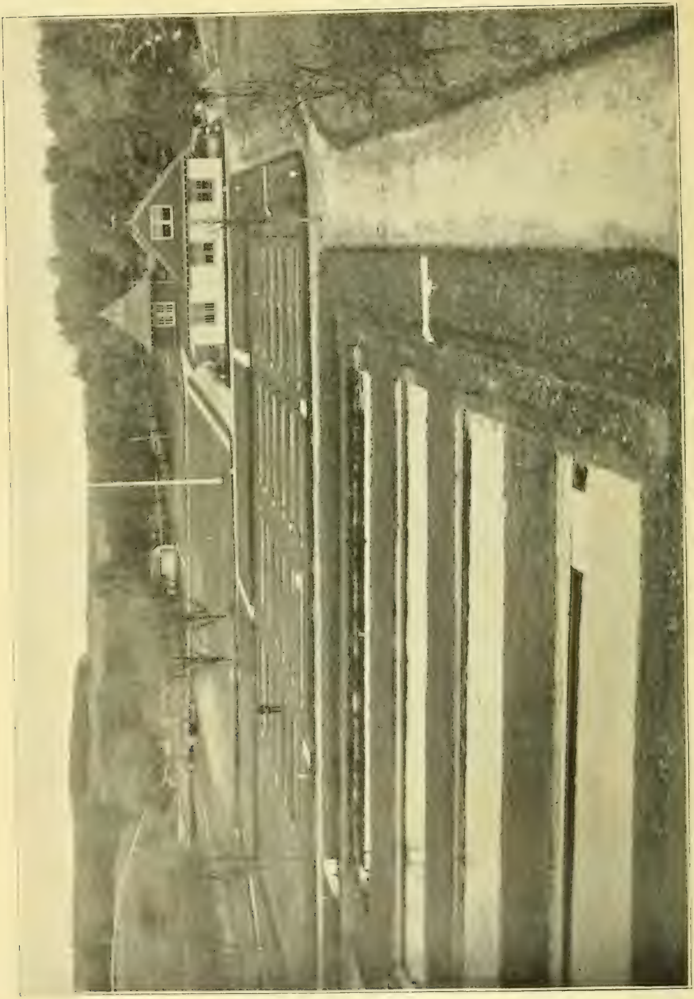


MANCHESTER STATION, IOWA, REARING PONDS AND HATCHERY.

REPORT

OF THE

UNITED STATES COMMISSIONER OF FISH AND FISHERIES

FOR THE

FISCAL YEAR ENDING JUNE 30, 1898.

I have the honor to submit a report of the work of the United States Commission of Fish and Fisheries for the year ending June 30, 1898, together with the reports of the assistants in charge of its divisions, which, with the papers describing special investigations, published as appendices to this report or in the Bulletin of the Commission, form a complete record of its operations for this period. The Commission was under the direction of Commissioner John J. Brice until February 16, 1898, when the present Commissioner, George M. Bowers, appointed February 1, took charge.

In view of the marked increase of the work of the Commission and the addition of the new stations authorized each year by Congress, and the consequent enlarged demands on its resources, it is impossible to carry on its operations in such manner as to obtain the best results with the present appropriation, which is small considering the important interests at stake, representing millions of dollars invested in the fisheries and allied interests throughout the country. It is, therefore, earnestly recommended that the estimates submitted, embodying certain increases, be favorably acted on by Congress, particularly those items providing for the propagation of food-fishes and for the contingent expenses required for scientific and statistical investigations, the demands for which are steadily increasing.

Special technical information is frequently desired for important objects, such as protective legislation by the States or the extension or establishment of fishery enterprises, and this often involves extensive studies or investigations of aquatic life, which can be carried on only under Government auspices. Appropriations are needed for the improvement of the grounds and buildings at some of the stations, and the efficiency of several could be materially enhanced by additions to their water supply and enlargement of their pond systems. The stations are always places of public interest in their respective neighborhoods, and while they are not designed for parks or pleasure-grounds it appears eminently proper that they should be made attractive and beautified to a certain degree.

While the division reports describe the work in detail, attention may be called to the progress made in fish propagation, and to some of the more important investigations and canvasses carried on by the Divisions of Inquiry respecting Food-fishes and of Statistics.

DIVISION OF FISH-CULTURE.

The operations of this division were in many respects more important than in any past year, owing in part to the natural growth of the work and in part to greater efficiency in dealing with the various questions and problems that come up for consideration.

The propagation and distribution of food-fishes during the present fiscal year exceeded by about 40 per cent the work accomplished in any other similar period. The number of adult and yearling fishes, fry, and eggs distributed in public and private waters or transferred to the State authorities was about 857,000,000, of which the largest number represented important commercial species, like the shad, cod, whitefish, salmon, lake trout, herring, pike perch, and lobster. There were 33 hatching stations and substations in use, the one located at Erwin, Tenn., having been completed and placed in operation in addition to those mentioned last year. The steamer *Fish Hawk* was also utilized for shad-hatching in Albemarle Sound and the Delaware River.

A comparison of the output for this year with that of last shows a marked expansion in the hatching of shad, Pacific salmon, and cod. The extension of the salmon-hatching work on the Pacific coast was especially gratifying, as the enormous annual drain on the salmon streams of that region makes it very important that the supply should be kept up by artificial means. At the substation situated on Battle Creek, a tributary of the Sacramento River, the largest collection of salmon eggs (48,000,000) in the history of fish-culture was made in the fall of 1897.

Although there are several desirable species of salmon in the Pacific rivers, the Commission gives its principal attention to the chinook or quinnat salmon, which is the species most desired for canning and fresh consumption. Some light has been thrown on the results of fish-cultural work on the west coast by the recent capture of a considerable number of large salmon with the soft dorsal fin missing. These are fish that were liberated from the Government hatcheries about three years ago, when they were less than a year old, after having been marked by the removal of the adipose fin. The work of the Commission is very popular in the West, and its value is generally recognized by the salmon fishermen and canners.

The wall-eyed pike or pike perch, *Stizostedion vitreum*, is one of the most valuable of the fishes of the Great Lakes. In Lake Erie, where by far the largest part of the catch is taken, it ranks first in money value. The fishing interests being desirous that the Government should keep up the supply, the propagation of this species, which had been discontinued for several years, was resumed in the spring of 1898 at

Put-in-Bay Station, on Lake Erie, 221,062,500 eggs being collected. It was also designed to take up this work on Lake Ontario, where formerly there was a comparatively large catch, but after careful investigation it was found that but few spawning fish were found on fishing-grounds that a few years ago yielded tons of fish. This disappearance from their usual spawning-grounds was attributed by some to the discharge of refuse from mills and factories into the tributaries of Lake Ontario. 30,000,000 of the eggs collected at Put-in Bay were transferred to the Lake Ontario station, and the fry resulting from them were planted in the St. Lawrence.

The passage of laws by the State of Michigan prohibiting the capture of whitefish and lake trout in Lakes Huron and Michigan from November 1 to December 15, unfortunately caused the abandonment of whitefish work on these lakes. Efforts were made to collect eggs at Duluth, but very few were secured.

At Put-in Bay, Lake Erie, notwithstanding the unfavorable weather that prevailed during the fall, 112,842,000 whitefish and 27,786,000 cisco or lake-herring eggs were collected from fish taken by the commercial fishermen; 10,000,000 of these were sent to Alpena, Mich., to be hatched and liberated in Lake Huron.

Further experiments were conducted on Lake Erie to determine the practicability of holding in pens the adult whitefish taken prior to the spawning season; 1,200 fish were secured from the fishermen in the vicinity of Put-in Bay and impounded in floating live-boxes, and over 10,000,000 eggs were thus secured. The results of the experiment, though not as large as anticipated, are encouraging, and will probably lead to a considerable extension of whitefish propagation in Lake Erie, as in this way a definite supply of spawners can be depended on. Stormy weather has in the past often prevented the taking of sufficient numbers of fish during the spawning season. In conducting this experimental work great assistance was rendered by the fishermen, who allowed the Commission to take fish from their pound nets without charge and hold them in live-boxes until after the spawning season, when they were returned to the fishermen.

The lake-trout work at Northville and Alpena stations in Michigan was larger than heretofore, notwithstanding that the passage of the act previously referred to cut short the collecting season materially and few eggs could be obtained from grounds that had in the past yielded large numbers. There is little doubt that under ordinary conditions the collections for Northville, which reached 12,000,000, would have doubled that amount.

The propagation of marine species, such as cod, flatfish, pollock, and lobsters, was the object of attention on the Atlantic Coast, at the Woods Hole and Gloucester stations. Profiting by the preliminary investigation made during the previous year, large numbers of cod eggs were obtained at Plymouth, which, with those taken from the brood-fish held at Woods Hole, made an aggregate of 153,436,000 eggs, which yielded

105,863,000 fry. Over 160,000,000 eggs were also collected at Kittery Point, Maine, which were transferred to the Gloucester Station, from which 96,700,000 cod fry were hatched and liberated.

During the months of November and December between 7,000,000 and 8,000,000 pollock eggs were collected from boats fishing out of Gloucester, and the fry resulting from them were planted in neighboring waters. It was intended to take up the propagation of this species on a large scale, but most of the pollock in that vicinity are now captured with hand lines instead of gill nets, making it impossible to obtain spawning fish in quantities.

The constant decline in the lobster fishery accentuates the necessity for increased work in this line. The schooner *Grampus* was employed during the months of April, May, and June in collecting egg lobsters along the entire coast of Maine. The fisheries on the coasts of Massachusetts, Rhode Island, and Connecticut were looked after by fishing smacks and steam launches, and as a result of these efforts 95,000,000 fry were liberated.

During the spring of 1898 over 300,000,000 shad eggs were collected on the Delaware, Susquehanna, and Potomac rivers, and in the Albemarle Sound, North Carolina; 228,000,000 of these eggs were hatched and the fry planted—a very satisfactory increase over the previous year. The usual shad operations on the Delaware with the *Fish Hawk* were interrupted by the war, which caused the detail of that vessel for naval service. To prevent the abandonment of the work, arrangements were made with the Pennsylvania authorities to operate the State hatchery at Bristol.

An important new feature of the fish-cultural work was the hatching of 3,000,000 fry of the grayling at Bozeman Station. This fine food and game fish has a very limited distribution, and its artificial propagation has heretofore been chiefly experimental.

The efforts to acclimatize food-fishes in waters to which they are not indigenous have been continued by transferring quantities of eggs of the quinnat salmon and steelhead trout to eastern stations to be hatched, so that the fry could be planted in Atlantic coastal streams. Adult tautog, lobsters, and blue crabs have been sent to California and planted in the Pacific. Many of the lobsters were females with eggs, and the plant should result in from 3,000,000 to 4,000,000 fry besides the adult lobsters.

The steady increase in the catch of shad in the United States is conclusive evidence of the value of artificial propagation. In the year 1880, prior to which time but little work of this character had been done, the catch of shad in the United States was 18,074,534 pounds; and in the years immediately succeeding 1880 until 1885, when the first results of artificial propagation became observable, the supply of these fish had decreased to such an extent that it was feared they would be exhausted for commercial purposes. In 1888 the catch had increased to 35,736,585 pounds, and in 1896, the last year for which

there are accurate data, the catch was 50,866,368 pounds, or, in round numbers, 13,000,000 fish as against a little over 5,000,000 in 1880, an increase of over 150 per cent. The value of the shad fishery to the fishermen in 1880 was $995,790; in 1896 it amounted to $1,656,711. The Commission expended during the fiscal year 1896–97, $15,726.36, and in the following year $16,356.99 in the propagation and distribution of this species. At an average annual expenditure of $15,000 per annum since 1880, the total expended in the propagation of this species during sixteen years would amount to $240,000. As a consequence of the greater abundance of the fish the cost has been materially lessened, but even at the price actually received the increased 33,000,000 pounds was worth $1,049,000, or $809,000 more than has been expended by the Commission on the propagation of this species, exclusive of the cost of the stations, in sixteen years.

Table showing the number of fish and eggs furnished for distribution by the various stations.

Source of supply.	Species.	Eggs.	Fry and fingerlings.	Adults and yearlings.
Green Lake, Me	Golden trout	10,000	79,144	
	Brook trout	25,000	321,721	
	Lake trout	75,000	70,998	
	Steelhead trout		22,966	
	Quinnat salmon		901,066	
	Landlocked salmon	111,243		121,830
	Atlantic salmon			16,208
Craig Brook, Me	Atlantic salmon	400,000	1,975,070	203,697
	Atlantic salmon domesticated			829
	Landlocked salmon	60,000		1,960
	Quinnat salmon			235,935
	Steelhead trout		35,941	6,552
	Scotch sea trout			1,589
	Rainbow trout			355
St. Johnsbury, Vt	Brook trout	120,300	561,000	
	Lake trout		14,000	
	Steelhead trout		106,626	
	Landlocked salmon		3,928	
Gloucester, Mass	Cod		96,707,000	
	Pollock		4,455,000	
	Lobster		65,097,000	
Woods Hole, Mass	Cod		105,863,000	
	Flatfish		39,337,000	
	Lobster		30,192,000	
Cape Vincent, N. Y	Lake trout		982,331	
	Steelhead trout		90,060	
	Brook trout		56,000	
	Quinnat salmon		4,691,801	
	Atlantic salmon		97,071	
	Pike perch		10,043,750	
Steamer Fish Hawk	Shad	1,811,000	5,647,000	
Bristol, Pa	do		15,460,000	
Battery Station, Md	do	68,881,000	75,490,000	
Fish Ponds, D. C	do			3,036,000
	Black bass, large-mouth			14,222
	Black bass, small-mouth			1,837
	Crappie			779
Central Station, D. C.	Shad	5,179,000	5,717,000	
	Loch Leven trout		7,282	
	Rainbow trout		7,948	
	Brook trout		8,668	
	Lake trout		19,640	
	Landlocked salmon		3,085	
Bryan Point, Md	Shad		47,366,000	
Wytheville, Va	Rainbow trout	130,000	25,000	169,295
	Rock bass			7,898
Put-in Bay, Ohio	Lake trout		908,800	
	Whitefish	200,000	80,290,000	
	Lake herring		18,970,000	
	Pike perch		71,110,000	
	Black bass, large-mouth			2
	Black bass, small-mouth			89
	Rock bass			268
	Sunfish			69

Number of fish and eggs furnished for distribution by the various stations—Continued.

Source of supply.	Species.	Eggs.	Fry and fingerlings.	Adults and yearlings.
Northville, Mich	Lake trout	1,010,000	3,543,000	
	Brook trout	2,000	228,000	1,000
	Loch Leven trout	5,000	8,000	
	Steelhead trout		85,000	3,500
	Rainbow trout			8,000
Alpena, Mich	Lake trout		1,445,000	
	Whitefish		8,100,000	
Duluth, Minn	Lake trout		5,143,000	
	Brook trout		92,550	
	Steelhead trout		130,000	
	Whitefish		98,000	
Quincy, Ill	Black bass			24,808
	Crappie			3,103
Manchester, Iowa	Rainbow trout		4,000	
	Brook trout		19,000	
	Lake trout		437,000	
Neosho, Mo	Rainbow trout		14,000	73,219
	Black bass			10,101
	Rock bass			13,618
	Strawberry bass			5,912
San Marcos, Tex	Black bass			30,755
	Rock bass			3,700
	Crappie			50
Leadville, Colo	Brook trout	172,000	581,000	172,100
	Black-spotted trout		270,000	
	Rainbow trout		21,000	
	Yellow-fin trout		7,500	
	Loch Leven trout	15,000		8,000
Bozeman, Mont	Brook trout			6,000
	Steelhead trout			45,000
	Grayling		1,500,000	
Baird Station, Cal	Quinnat salmon	6,555,000	6,511,800	
Fort Gaston, Cal	do		1,276,000	
	Rainbow trout		35,950	4,085
	Steelhead trout	60,000	650,000	
Olema, Cal	Quinnat salmon		1,970,000	
Battle Creek, Cal	do	24,050,000	5,885,500	
Clackamas, Oreg	do		10,029,796	
	Loch Leven trout		5,175	
Upper Clackamas, Oreg	Quinnat salmon		4,390,000	
Salmon River	do		145,396	
Rogue River	do		1,910,045	
Little White Salmon	do		7,391,886	
Mapleton, Oreg	do		440,275	

Summary of distribution.

Species.	Eggs.	Fry and fingerlings.	Adults and yearlings.	Total.
Shad	75,871,000	149,155,000	3,036,000	228,062,000
Quinnat salmon	30,605,000	45,543,558	230,200	78,378,758
Atlantic salmon	400,000	2,072,139	220,635	2,692,774
Landlocked salmon	171,243	7,005	121,088	299,336
Steelhead trout	60,000	1,113,354	53,572	1,226,926
Loch Leven trout	20,000	20,457	8,000	48,457
Rainbow trout	130,000	96,022	249,532	475,554
Black-spotted trout		258,400		258,400
Brook trout	319,300	1,863,798	161,391	2,344,489
Lake trout	1,085,000	12,521,219		13,606,219
Scotch sea trout			1,589	1,589
Yellow-fin trout		7,500		7,500
Golden trout	10,000	79,144		89,144
Grayling		1,500,000		1,500,000
Whitefish	200,000	88,488,000		88,488,000
Pike perch		81,153,750		81,153,750
Lake herring		18,970,000		18,970,000
Black bass, large-mouth			76,064	76,064
Black bass, small-mouth			1,884	1,884
Crappie			3,369	3,369
Sunfish			69	69
Rock bass			23,352	23,352
Strawberry bass			5,912	5,912
Cod		202,570,000		202,570,000
Pollock		4,455,000		4,455,000
Flatfish		39,337,000		39,337,000
Lobster		95,234,000		95,234,000
Total	108,871,543	744,445,346	4,192,657	857,309,546

BIRD'S-EYE VIEW OF ST. JOHNSBURY STATION, VERMONT.

The cars of the Commission traveled 98,964 miles and detached messengers 121,160 miles while distributing fishes during the year. The Commission was again the recipient of material assistance from many railroads, as shown by the following list of roads giving free transportation, without which the work would have been much curtailed:

Name of railroad.	Cars.	Messengers.
	Miles.	*Miles.*
Atchison, Topeka and Santa Fe Rwy	7,723	
Atlantic Coast Line	792	
Austin and Northwestern R. R		198
Bangor and Aroostook R. R	66	
Bennington and Rutland Rwy		34
Boston and Albany R. R	26	
Boston and Maine R. R	460	1,938
Burlington, Cedar Rapids and Northern Rwy	2,330	228
Burlington and Missouri River R. R. in Nebraska	1,025	
Carolina and Northwestern Rwy	189	28
Central Vermont R. R		292
Chesapeake and Ohio Rwy	2,355	
Chicago, Burlington and Quincy R. R	1,306	1,463
Chicago, Milwaukee and St. Paul Rwy	1,510	
Chicago and West Michigan Rwy	1,686	296
Cleveland, Cincinnati, Chicago and St. Louis Rwy	1,833	
Colorado Midland Rwy	556	70
Delaware and Hudson R. R	374	
Denver, Leadville and Gunnison Rwy		3,332
Denver and Rio Grande R. R	1,944	5,206
Detroit, Grand Rapids and Western R. R	921	256
Detroit and Mackinac Rwy	1,268	122
Detroit, Toledo and Milwaukee R. R	312	
Duluth and Iron Range R. R		264
Duluth, South Shore and Atlantic Rwy	1,222	
East Tennessee and Western North Carolina R. R		34
Erie R. R		181
Flint and Pere Marquette R. R	3,060	1,415
Fort Worth and Denver City Rwy	258	1,544
Grand Rapids and Indiana Rwy	226	
Grand Trunk Rwy. System		8
Great Northern Rwy	1,919	
Gulf, Colorado and Santa Fe Rwy	342	751
Houston and Texas Central R. R		1,748
Houston, East and West Texas Rwy		236
Hunter's Run and Slate Belt R. R		16
Illinois Central R. R	444	1,545
International and Great Northern R. R		1,640
Kansas City, Fort Scott and Memphis R. R	576	
Kansas City, Pittsburg and Gulf R. R	586	348
Louisville and Nashville R. R	1,572	
Maine Central R. R	1,572	
Michigan Central R. R	5,409	
Manistique Rwy	62	
Minneapolis, St. Paul and Sault Ste. Marie Rwy	214	
Missouri, Kansas and Texas Rwy		2,325
Mobile and Ohio R. R	152	
Montana Union Rwy	14	
Montpelier and Wells River R. R		134
Nashville, Chattanooga and St. Louis Rwy	302	
New York, New Haven and Hartford R. R	484	
Northern Pacific Rwy	4,540	
Oregon R. R. and Navigation Co	869	
Oregon Short Line R. R	1,862	
Pennsylvania R. R	444	1,018
Plant System	1,086	
Richmond, Fredericksburg and Potomac R. R	164	
Rio Grande Western Rwy	1,240	
Rutland R. R		167
Rumford Falls and Rangeley Lakes Rwy		112
San Antonio and Aransas Pass Rwy		886
Sioux City and Northern R. R	97	
Southern Pacific Co. (Atlantic System)		794
Southern Rwy	1,120	
St. Johnsbury and Lake Champlain R. R		802
St. Louis Southwestern Rwy	526	831
Texas and Pacific Rwy	492	336
Union Pacific, Denver and Gulf Rwy	154	744
Union Pacific System	4,582	
Wabash R. R		1,976
Wisconsin Central R. R	901	
Woodstock Rwy		28
Total of free transportation	63,167	33,346

DIVISION OF INQUIRY RESPECTING FOOD-FISHES.

The most valuable of the fishery resources of the country, the oyster, has been the subject of a number of special investigations. Pursuant to a request from the legislature, governor, and citizens of Louisiana, Lieut. Franklin Swift, U. S. N., was directed to proceed with the steamer *Fish Hawk* to make a survey of the oyster-grounds of that State, in order to furnish accurate information on which to base a revision of the oyster laws, with a view to putting the oyster industry on a more substantial footing. The vessel reached Mississippi Sound on January 31, and confined her work to the oyster-beds of St. Bernard Parish. While there was not sufficient time to complete the survey of all the oyster-grounds of the State, Dr. H. F. Moore, who took part in the investigation as zoologist, made an examination of them. It was found that the fishing methods pursued have been very injurious, in some instances resulting in the practical destruction of the oysters, and that with the adoption of improved methods and proper restrictions the oyster-planting industry might be greatly extended. The report of Dr. Moore has been transmitted to the governor of Louisiana.

The prevalence of green oysters in the Chesapeake region and elsewhere having proved very serious, financially, to the oyster-growers, has received the prompt attention of the Commission. It is the general opinion among oyster-consumers that green oysters derive their color from copper, with which they have been contaminated, and are therefore unwholesome. This belief results in large losses to oystermen, who are prevented from marketing the crop when the greenness is marked. It has been demonstrated repeatedly and announced by the Commission that the green oysters owe their color to vegetable matter which serves as food, and that no impairment in the food value of the oyster results from this condition. The announcement in the press of the discovery of copper in considerable quantities in English oysters led the Commission to make a reexamination of the subject with the result that previous tests were confirmed.

Experiments in fattening oysters for the market have been conducted at Lynnhaven, Va., where the Commission has constructed special ponds for the purpose.

The desire of the Commission to give the people of the Pacific coast a plentiful supply of eastern oysters has resulted in the shipment of a number of carloads to suitable points in California and Oregon, the plants being guarded by the local authorities during the time required for their acclimatization and propagation. In order to determine the condition of the introduced oysters, the Commission detailed Professor Washburn, of Oregon University, to visit and report on the beds. The observations, extending over the years 1897 and 1898, show that all the planted oysters have survived and grown, although there are as yet no evidences of an increase in numbers.

A canvass of the sponge fisheries of Florida was made in 1896, and to determine the relative conditions of this industry a second inquiry

was made by Dr. Hugh M. Smith in January, 1898. The second investigation emphasized the necessity of action on the part of the State to prevent serious injury to the fisheries. During the past few years the aggregate quantity of sponges taken has steadily increased, but the increase has resulted from more extended fishing as well as from the taking of sponges of less than the legal size. The present catch is also made up of comparatively large quantities of inferior varieties, as is shown by the fact that in 1895 the output of sheepswool sponges, the best variety and that of most commercial value, comprised 76 per cent of the total catch, while in 1897 it had fallen to 47 per cent. Though the sponge-grounds have been seriously affected by excessive and illegal fishing, they may yet be renewed and become capable of yielding large returns by the adoption of remedial measures, as suggested in Dr. Smith's report, published in the Bulletin for 1898.

From time to time during recent years reports have been received of the capture of shad in the tributaries of the Mississippi. Beginning with the spring of 1896, these fish had been taken each year in some numbers at various points in the Mississippi, Ohio, and Kanawha rivers. An opportunity was afforded of examining specimens taken in May, 1898, and a visit was made by Dr. B. W. Evermann to the localities where the capture of the fish was reported, and interesting observations were made. The fish were found to be a species of true shad, apparently resembling, though not identical with, the shad of the Atlantic coast rivers and the species of shad found in Alabama. They are apparently indigenous to the rivers of the Mississippi Valley, and not the results of plants of shad formerly made in those waters.

During the summer of 1897 the biological surveys in the Northwest, which have been in progress for several years, were carried on by field parties, chiefly under the direction of Dr. B. W. Evermann. In continuation of the studies of the spawning habits of the redfish in the lakes of the Northwest, a comprehensive investigation was made of Wallowa Lake in Oregon. An examination was also begun of a series of isolated lakes lying along the southern border of Oregon, about whose fauna nothing has been known. A party visited these lakes in July and August to study their physical and biological features and to make collections of fishes and other animals inhabiting them. With the completion of these investigations and a study of the collections much light will be thrown on the characteristics of the isolated fish fauna and the origin of the fauna of these and similar lakes of Oregon, California, and Nevada.

Explorations were made of the principal coastal streams of California, Washington, and Oregon, and biological examinations carried on to determine their physical characteristics, the nature of their fish fauna, and the abundance and habits of the different species of fishes frequenting them.

The studies of the movements, habits, growth, etc., of young shad in the Potomac, and of young salmon in the Sacramento, have been

continued and are affording interesting information which will be of value in the propagation of these fishes; and investigations in Lake Superior, which were begun in April, 1897, having for their object the determining of the food supply of the fishes of that lake, will, when finished, yield information of value in the planting of fish fry. Large collections of minute animal life have been made from Lake Superior, the study of which has not as yet been completed.

On account of the survey of the fur-seal rookeries made by the United States Coast and Geodetic Survey in the summer of 1897, and the second visit to the seal islands of the special commissioners who were appointed the previous year to report on the conditions of seal life, it was not deemed necessary by the Secretary of the Treasury for this Commission to send an agent to the islands to make the usual investigations. Arrangements were made through the courtesy of the special commissioners to obtain for this office photographs of the rookeries and the requisite data to continue its series of maps showing the changes in condition of the fur-seal rookeries from year to year.

The subject of the pollution of rivers and streams by mill and factory refuse, and the discharge of sewage from the towns and cities on their banks, is receiving much attention from those interested both in maintaining proper sanitary conditions and in the preservation of fish life. A memorial prepared by the Game and Fish Protective Association of the District of Columbia, urging the importance of action in this matter, was presented to Congress March 17, 1898, and published as Senate Document 194, Fifty-fifth Congress, second session. At the request of the chairman of its committee, a letter containing extracts from publications of this Commission, showing the evil effects produced upon fish life by the contamination of streams, was submitted by this office to the association for incorporation in the memorial. As stated in this letter, "the data are sufficient to clearly establish the point that river pollution is both directly and indirectly most injurious to fish and the fisheries by destroying fish and fish eggs, by driving fish away, by interfering with the fishing apparatus, and by killing or impairing the supply of minute animals and plants which are the basis of fish life." Remedial legislation is greatly to be desired in many localities.

During the summer of 1897 the Woods Hole laboratory was occupied by a small number of investigators, the attendance having been restricted to representatives of those institutions which had furnished financial aid in the establishment of the laboratory. The continued scarcity of mackerel rendered it important to continue the study of these fishes with a view to the satisfactory solution of the problem of their artificial propagation on a large scale, and among the inquiries carried on at Woods Hole was an investigation by Dr. J. Percy Moore relative to the embryology, natural history, and artificial propagation of the mackerel. The report of Dr. Moore is published as an appendix to this report (pages 1–22).

In the spring of 1898 steps were taken to increase the opportunities for scientific study at Woods Hole and to keep the laboratory open

during the entire year. Dr. H. C. Bumpus, of Brown University, was appointed director. The laboratory was opened on March 14, and by June 1 accommodations for the summer had been assigned to investigators to the full capacity of the station, and the season's work was in satisfactory progress.

DIVISION OF STATISTICS AND METHODS OF THE FISHERIES.

The principal work of this division has consisted of canvasses of the more important fisheries of certain of the New England and Middle Atlantic States and the Great Lakes, begun in August, 1897, and the South Atlantic and Gulf States, carried on in the spring of 1898. The results of the earlier field work were at once published in the form of bulletins, which were distributed to commercial organizations, boards of trade, and newspapers, and sent to custom-houses and post-offices, where they could be posted for the benefit of those interested in the regions to which reference was made.

At Gloucester and Boston there has been a falling off in the aggregate receipts of fish at the two ports since 1896. During the calendar year 1897 there were landed from American vessels at both places 126,685,598 pounds, worth to the fishermen $2,878,635. Each port participated in the decrease, though owing to certain changes in the conditions affecting the business more fares were landed at Gloucester than during the preceding year.

The fisheries of Lake Ontario have shown a steady decrease for many years, and the yield of the past year does not really represent the commercial importance of the fisheries. The yield in 1897 was only 920,996 pounds of fish, valued at $34,295, though the canvass shows more decrease in the quantity and value of the herring taken than with those species of more importance. A slight increase in whitefish is shown. The numerous resorts on this lake, frequented by anglers and pleasure-seekers, afford better employment to the fishermen during the season than fishing for the market. The falling-off in the supply of important fishes is due to a variety of causes, the conditions of which have already been discussed in the publications of this Commission.

The canvass of the South Atlantic States shows an increase as a whole since 1890 in the product, the amount of capital invested, and the number of persons employed. The increase was shared in by the States of North and South Carolina and Georgia, while the fisheries of the east coast of Florida have somewhat decreased. The total in 1897 was 80,390,465 pounds, with a value of $1,833,155. The increase was 12,674,400 pounds, valued at $252,191. The most important feature has been the marked improvement in the yield of shad and oysters in North Carolina and Georgia and of oysters in South Carolina.

On the Gulf coast some 2,200 more persons were employed than in 1890, but there has been a falling-off in the weight of fish taken, in the value of the product, and the amount of capital invested. This is undoubtedly due to unusual conditions. There have also been marked

changes in the relative values of the yield in different States. The total products amounted to 65,360,623 pounds, valued at $2,271,726 to the fishermen. The oyster fishery, valued at $748,760, was the most important, followed by the sponge fishery, valued at $355,589.

A market is developing in the Southern States west of the Mississippi River for the fishery products from southern California. Considerable shipments, consisting chiefly of barracuda, bonito, mackerel, sea bass, and spiny lobsters, have been made and have brought remunerative prices. Though the industry is yet in its infancy, it would appear that a new and increasing market will be found for California fresh fish and spiny lobsters.

Attention is called in the report of the division (page CLXV) to the fishery resources of the Yukon River, in Alaska, which thus far have only been utilized by the Indians for their own needs. The present information is fragmentary and inconclusive, but there is reason to believe that the abundance of salmon, whitefish, and other valuable species in this river will afford a food supply to the miners and traders located along its banks, and possibly become a factor in the fisheries of the country at large.

Appended to the report of the division are statistical tables relating to the fisheries of the Gulf States, the South Atlantic States, Boston and Gloucester, Mass., San Diego, Cal., and Lake Ontario, and tables showing the yield and value of certain fisheries of New England, the Middle Atlantic States, and the Great Lakes.

INVESTIGATIONS OF THE ALBATROSS.

At the beginning of the fiscal year the steamer *Albatross*, under command of Lieut. Commander Jeff. F. Moser, U. S. N., was engaged in an investigation of the fishery resources of Alaska, and this inquiry was continued until the stormy weather of fall compelled the return of the vessel to more southern latitudes.

Especial attention was given to the salmon fishery, and the report of Captain Moser, to be published in the Bulletin of this Commission for 1898, gives a full account of the expedition, and is an important contribution to this subject, supplying much-needed and detailed information.

Many of the waters visited had not been completely surveyed, and in consequence existing charts were found to be defective. In addition to the inquiries pertaining to the investigation much hydrographic work was done by Captain Moser, his notes of which, with accompanying chart corrections, have been forwarded to the Coast and Geodetic Survey.

The investigation embraced the physical characteristics of streams and their productive capacity, the species of salmon frequenting them, together with observations on the habits, sizes, and abundance of these fishes, and a comparison of their past and present abundance; the extent and methods of fishing operations and their effect on the supply

of fish; detailed statistics of the canneries and salteries, besides a general study of the subject.

All of the canneries in operation in Alaska outside of Bering Sea were visited, and as many streams explored as time would permit. Owing to the great extent of the Alaskan coast line and the character and number of its streams, it was impossible to visit them all in a single season, and no attempt was made to explore any except where redfish are found, as this species is of the most commercial importance. It had been intended to continue the investigation during the following year and carry it on until complete data are available regarding all the waters of the Territory, whether they are now fished or not, but further inquiries have been unavoidably postponed till another season, as, owing to the outbreak of the war with Spain, the *Albatross* was, on April 13, 1898, detailed by the President to the Navy Department for use as an auxiliary cruiser.

The examinations of streams were made with care, not only to determine what species of fish frequented them and to obtain complete records of them as salmon-producers, but also to discover what injury had been caused by the erection of traps and barricades, overfishing, etc. The explorations were often carried on with difficulty, owing to natural obstacles, and reliable information was difficult to obtain. At the Indian villages the reports were vague and confusing, and the whites were found to know but little of the streams, save where they themselves fish, and even these they but rarely trace to their sources to examine the spawning-grounds; moreover, large areas of the Territory are uninhabited except during the fishing season.

The most important species of salmon packed in Alaska is the redfish (*Oncorhynchus nerka*), known in other localities as the blueback, sockeye, and by various other names. The other species form but a small percentage of the output, and of these the more important are the humpback (*O. gorbuscha*) and coho (*O. kisutch*). The king salmon (*O. tschawytscha*), the well-known and valuable quinnat or chinook salmon of the Pacific States, is only found in small numbers, and in 1897 formed but little over 2 per cent of the total pack. In 1897, 688,581 cases of redfish and 157,711 cases of humpbacks were packed, 75.74 and 17.35 per cent, respectively, while the remainder of the production was made up of king salmon, cohoes, and dog salmon. The redfish is noted for its deep red color, and is preferred for canning for that reason, although other species, as the humpback and coho, might prove practically as good. The coho is more delicately flavored, has richer meat, and but for the popular prejudice in favor of the red flesh, should rank next to the king salmon in value.

The dates when the salmon arrive in sufficient quantities to be taken for commercial purposes vary largely in streams in the same neighborhood, the larger rivers and the streams nearer the sea usually receiving the first fish. As a rule the "run" from the sea to the rivers and streams for the purpose of spawning occupies practically the entire

season of open water, the different species following each other in somewhat regular sequence, so that the canneries are able to operate advantageously throughout the summer months and into the early fall. King salmon are taken as soon as the ice disappears in the spring, as early as May 6 at the Copper River, but the canneries usually begin to operate in June, as the run of redfish begins during that month. Except at Karluk, where the runs frequently extend to the first of October, cannerymen count on the supply of redfish lasting about six weeks, and the pack of this species is completed early in August. There is also considerable variation in the runs of cohoes, which follow the redfish, but which are taken in quantities from the first week in August until the canneries close, about September 20, though in one or two instances canneries commence packing cohoes as early as July. Humpbacks are said to be in condition for packing only about one month; the bulk of this species is packed in southeast Alaska, from the middle of July to the middle of August.

The fishing is carried on in the main by fishermen in the employ of the canneries, except in southeast Alaska, where, though the canneries have their own fishermen, a large part of the supply of fish is purchased from native or white fishermen. This supply is obtained under various arrangements, and frequently certain fishing rights are recognized by the canneries. These so-called rights have their foundation in prior discovery or—especially with the Indians—in continuous residence on or near the stream in question. The fisheries frequently give rise to disputes between the rival claimants to the different streams.

The streams of Alaska show the results of the enormous drains made on them by continuous fishing, and though it can not be asserted that the supply of salmon will fail entirely within a few years, there is no doubt that the streams are slowly becoming depleted. Canneries have increased in numbers, many of them have been enlarged, and the production of canned salmon is steadily increasing, but fewer salmon are caught now than formerly in the streams which have long been fished, notwithstanding the use of improved gear and appliances. Taking, for instance, a section of southeast Alaska, where, in 1889, four canneries produced 13,000 cases, and in 1897 produced double that pack—in 1889 the fish were nearly all redfish and taken from streams near the canneries, while in 1897 few redfish were taken, the pack being mainly composed of humpbacks; and yet, to obtain the supply, all the streams within 70 or 80 miles of the canneries had been fished with all the gear that could be used. Again, at another locality, where, from 1890 to 1896, an average of 61,400 cases annually were packed with fish taken from one stream by one establishment, in 1896 three canneries, putting forth great efforts to secure a large output, only packed 65,000 cases, and in 1897, with redoubled energy, 74,159 cases. Many such instances could be pointed out, but these will serve as illustrations of how the streams are being gradually depleted by the barricading of streams and overfishing—in other words, illegal fishing.

As the investigation progressed it was surprising to discover the number of streams which were, or had been barricaded, notwithstanding the strict laws prohibiting such obstructions. These conditions were more observable in southeast Alaska and Prince William Sound, as the streams there are small, easily closed, and numerous. The extensive and indiscriminate use of barricades is fatal to the natural maintenance of the salmon by preventing their ascent to the spawning-grounds. At the approach of the spawning period the salmon come to the rivers and streams, gathering in schools which grow larger and larger as the season advances, and after they have accustomed themselves to the brackish water at the mouths of the streams they are ready to ascend to the spawning-beds. If their progress is obstructed they remain in the bay or inlet about the approaches to the stream, endeavoring to pass the barricade, and thus are practically corralled and easily taken in great numbers at small expense.

It is maintained by the cannerymen that salmon held in brackish waters ripen less rapidly, and consequently by the operation of barricades they can be obtained in suitable condition for canning much later in the season.

The laws and regulations pertaining to the Alaska salmon fisheries are not very generally observed and do not prevent the illegal capture of fish. While in a minor degree the law may be defective, and owing to the varying conditions found in the vast extent of territory involved may need amending, still it is good as it stands and for the present only needs enforcement, and there is no doubt the proprietors of the canneries would be glad to see it enforced if it is done impartially.

Without considering the large amount of money invested in the canneries with their elaborate and expensive equipment, the output is worth in round numbers $3,000,000 a year, and unless effective steps are taken to prevent the indiscriminate and wasteful taking of salmon, it will be only a question of time before the cannery interests will suffer severely, and through causes for which they are in part responsible.

The canning industry in Alaska began in 1878, when two small establishments were operated at Klawak and Old Sitka, but its development really commenced in 1888, when there were 17 canneries in operation. The unusually large pack of that year attracted general attention to the business, and in consequence many new plants were erected. This resulted in an output in excess of the demand, which caused the abandonment of some of the enterprises, and also led to a consolidation of many of them into an association known as the Alaska Packers' Association. Of the 29 canneries of Alaska in operation in 1897, 17 belonged to this association, with an output of 669,494 cases, or nearly 74 per cent of the total pack.

Of the pack in 1897, southeast Alaska contributed 29.9 per cent; the Prince William Sound and Copper River region 6.6 per cent; the Cook Inlet region 6.5 per cent; the Kadiak and Chignik region 43.8 per cent, and the Bering Sea region 19.9 per cent.

The following statement of the salmon pack of Alaska for 1897, shows the daily capacity of the different canneries, the number of cases packed, and the average number of fish contained in each case:

Name of company and location of cannery.	Daily capacity (cases).	Redfish.		Cohoes.		Humpbacks.		King and dog.	
		Number of cases packed.	Average number per case.	Number of cases packed.	Average number per case.	Number of cases packed.	Average number per case.	Number of cases packed.	Average number per case.
Quadra Packing Co., Boca de Quadra	500	7,500	......	3,000	......	14,000	......	......	......
Metlakahtla Industrial Co., Metlakahtla, Annette Island	600	7,090	......	840	......	7,260	......	[1] 300	......
Pacific Steam Whaling Co., Hunter Bay, Prince of Wales Island	800	13,162	13	5,300	7	15,926	19	......	......
Alaska Salmon Packing and Fur Co., Loring, Naha Bay	1,800	10,470	11.5	2,306	8.5	49,264	23	......	......
Boston Fishing and Trading Co., Yes or McDonald Bay	800	6,754	9	1,644	6	12,806	15	[2] 1,096	6
Glacier Packing Co., Point Highfield, Wrangell Island	1,500	7,428	9.5	8,620	8.8	28,624	23.1	[3] 1,246	3.9
North Pacific Trading and Packing Co., Klawak, Prince of Wales Island	500	9,520	13	1,995	8 to 9	4,190	22	......	......
Baranoff Packing Co., Redfish Bay, Baranoff Island	500	4,058	11	1,576	5	8,436	23	......	......
Pyramid Harbor Packing Co., Pyramid Harbor, Chilkat Inlet	1,600	31,241	10.3	1,488	7.5	......	......	[3] 4,727	3.1
Peninsula Trading and Fishing Co., Coquenhena, Copper River Delta	800	......	......	......	......	......	......	......	......
Pacific Packing Co., Odiak, Prince William Sound	1,500	13,315	12.7	......	......	9,784	24.5	[3] 202	4.8
Pacific Steam Whaling Co., Orca, Prince William Sound	1,500	21,927	9.5	3,414	7.5	3,415	18.7	......	......
Arctic Fishing Co., Kussilof River, Cook Inlet	1,500	24,701	14.1	2,313	12.1	......	......	[3] 5,518	2.5
Hume-Aleutian Packing Co., Karluk, Kadiak Island	2,600	49,633	11.9	......	......	......	......	......	......
Karluk Packing Co., Karluk, Kadiak Island	2,600	54,777	11.9	......	......	......	......	......	......
Alaska Improvement Co., Karluk, Kadiak Island	1,500	49,852	11.9	......	......	......	......	......	......
Arctic Packing Co., Alitak Bay, Kadiak Island	1,500	37,401	13.7	......	......	......	......	......	......
Pacific Steam Whaling Co., Uyak Anchorage, Kadiak Island	800	17,000	12	......	......	......	......	......	......
Hume Brothers & Hume, Uyak Anchorage, Kadiak Island	800	13,375	12.7	......	......	......	......	......	......
Uganuk Fishing Station, Uganuk Bay, Kadiak Island	1,400	2,113	10	......	......	......	......	......	......
Chignik Bay Co., Chignik Lagoon, Chignik Bay	2,600	36,834	12.4	942	11	[4] 383	15	......	......
Hume Brothers & Hume, Anchorage Bay, Chignik Bay	800	12,000	12	......	......	......	......	......	......
Pacific Steam Whaling Co., Anchorage Bay, Chignik Bay	800	23,500	12	......	......	500	20	......	......
Arctic Packing Co., Nushagak River, Bering Sea	2,000								
Alaska Packing Co., Nushagak River, Bering Sea	2,000	88,791	14	10,119	......	3,123	......	5,823	3
Bristol Bay Canning Co., Nushagak River, Bering Sea	2,000								
Point Roberts Packing Co., Kvichak River, Bering Sea	2,000	55,382	12.4	......	......	......	......	126	2.7
Arctic Packing Co., Naknek River, Bering Sea	1,800	34,496	12.4	......	......	......	......	180	......
Naknek Packing Co., Naknek River, Bering Sea	1,500	18,000	12	......	......	......	......	......	......
Bering Sea Packing Co., Ugashik River, Bering Sea	1,200	......	......	......	......	......	......	......	......
Ugashik Fishing Station, Ugashik River, Bering Sea	1,800	38,261	12	......	......	......	......	11	......
Totals	......	688,581	......	43,557	......	157,711	......	[5] 19,229	......

[1] Mixed. [2] Dog salmon. [3] King. [4] Humpbacks and dog salmon. [5] Includes dog salmon.

Considerable quantities of salmon are taken which for various reasons can not be utilized in canning, and are therefore salted. The output

of the salteries of Alaska for 1897 may be given as 10,658 barrels of redfish, 660 barrels of cohoes, 292 barrels of king salmon, 5,691 half barrels of humpback bellies, and 575 half barrels of miscellaneous.

The general importance of the salmon resources of Alaska may be seen from the following summary of the pack of canned salmon, classified by districts, from 1878—the year in which the business began—to 1897. From the very small initial pack of 8,159 cases the output has grown in less than twenty years to nearly 1,000,000 cases, the pack in 1896 being 966,000 cases and that in 1897 909,000 cases. In the regions of Cook Inlet, Prince William Sound, and Copper River salmon fishing is as yet comparatively light, but in southeastern Alaska, in Bering Sea, and at Kadiak and Chignik it is very extensive and tends to increase each year. The quantity of fresh salmon represented by the pack of 1897 was about 60,000,000 pounds, and the weight of the fish as canned was nearly 44,000,000 pounds.

The total pack of canned salmon in the twenty years indicated is seen to have been 7,508,358 cases of 48 one-pound cans. This quantity, with the 145,000 barrels of salmon which have been salted in the same period, represents over 600,000,000 pounds of fresh salmon taken from the waters of Alaska. The market value of the canned and salted product was a little over $32,000,000.

Summary, by districts, of the cases of salmon canned in Alaska from 1878 to 1897.

Year.	Southeast Alaska.	Prince William Sound and Copper River.	Cook Inlet.	Kadiak and Chignik.	Bering Sea.	Total.
1878	8,159					8,159
1879	12,530					12,530
1880	6,539					6,539
1881	8,977					8,977
1882	11,501		6,044	4,200		21,745
1883	18,040		14,818	13,479		46,337
1884	19,189		21,141	20,156	400	60,886
1885	10,828		19,217	33,470	14,000	77,515
1886	18,160		28,433	46,150	48,822	141,565
1887	31,462		30,765	71,750	72,700	206,677
1888	81,128		42,451	198,650	89,886	412,115
1889	136,760	24,204	50,494	386,753	115,985	714,196
1890	142,901	42,194	28,655	350,451	118,390	682,591
1891	156,615	68,091	58,997	384,279	133,418	801,400
1892	115,722		20,741	274,755	63,499	474,717
1893	136,053	76,998	31,665	291,152	107,786	643,654
1894	142,544	78,663	34,033	322,356	108,844	686,440
1895	148,476	59,494	36,188	232,237	150,135	626,530
1896	262,381	92,866	34,767	358,357	218,336	966,707
1897	271,867	52,057	32,532	298,310	254,312	909,078
Total	1,739,832	494,567	490,941	3,286,505	1,496,513	7,508,358

During the cruise of the *Albatross* fishery trials were carried on whenever opportunity offered, the efforts being especially directed toward the location of halibut banks. Halibut trawls were set in all localities, and every opportunity was taken to make inquiries. These fish were obtained everywhere, but not in large numbers excepting off Killisnoo. No great success was met with at Clarence Strait, which is a favorite halibut-ground, and the small vessels which sometimes visit this point for halibut have no certainty of finding a load. The Indians take without difficulty a sufficient supply for their own use, and, while

a fishing vessel might fill up, no great banks are known which can be relied on to supply a considerable market. South of Dixon Entrance, in the waters of British Columbia, halibut are found in large numbers throughout the winter, and in the spring are found in limited numbers in the waters of southeast Alaska.

THE STEAMER FISH HAWK.

The constant service of this vessel since she was last thoroughly overhauled in 1890 had necessitated extensive repairs, besides new boilers to supply the place of those which had been in use since 1887. Accordingly, on the completion of the mackerel work in July, 1897, the vessel was dismantled and sent to East Boston to receive a new main and auxiliary boiler. A new propeller, propeller shaft, and evaporator were added, and such other general repairs made to the machinery and joiner work as were essential to render the vessel perfectly seaworthy and serviceable. The hatching outfit also was renewed and the deck rearranged to permit an increase of the hatching capacity of about 50 per cent. Not only has the efficiency of the ship been greatly improved by these alterations and repairs, but she can now maintain an increased average speed at a considerable saving of coal and of wear on the machinery.

During the winter of 1897–98 the *Fish Hawk* was in attendance on the Fisheries Congress at Tampa, Fla., and afterwards engaged in a survey of the oyster-grounds in Louisiana, already referred to. At the conclusion of this duty, at the request of the United States Coast and Geodetic Survey, a hydrographic survey of Grand Bay, Alabama, was made in the latter part of February, 1898; and in March an investigation was conducted with reference to establishing a shad-hatchery on the Edisto River, South Carolina, but the conditions were found to be unfavorable.

When the shad season opened the usual fish-cultural work was taken up in North Carolina waters and in the Delaware River and carried on till May 4, 1898, when the vessel was, by order of the President, turned over to the Navy Department for service with the mosquito fleet during the war with Spain, her commander, Lieut. Franklin Swift, U. S. N., remaining with her. Lieutenant Swift had been in command of the *Fish Hawk* since June 27, 1895, and his services have been of great value to this Commission.

EXPOSITIONS.

The Tennessee Centennial Exposition, at Nashville, which was in progress at the close of the last fiscal year, came to an end October 31, 1897. The exhibit of the Commission, showing the workings of its various branches as described in the last annual report, attracted great attention from visitors, the specially interesting feature, as in other exhibits of the Commission, being the live fish displayed in the aquarium and the practical illustration of fish-culture, which was shown by the hatching of the eggs and the care of the fry of various species. There were hatched at different times during the season 3,500,000 shad

eggs; 10,000 trout eggs, and 20,000 eggs of the quinnat salmon. The resultant fry, after being placed on exhibition, were planted in suitable waters in Tennessee.

An act of Congress approved June 10, 1896, provided for the participation of the Executive Departments of the Government, the Smithsonian Institution, the United States Fish Commission, and the National Museum in the Trans-Mississippi and International Exposition to be held in Omaha, Nebr., from June 1 to November 1, 1898. Mr. W. de C. Ravenel, already in charge of the exhibit at Nashville, was appointed, on July 27, 1897, the representative of the Fish Commission on the Government board for the Omaha Exposition, and at the close of the exposition at Nashville arrangements were made to ship much of the material there collected to Omaha, and the other work of preparation for the latter exposition was promptly begun. The Omaha exposition is now in progress, and the exhibit of the Fish Commission, as on former occasions of this nature, is designed to show the character of the work of its branches, the methods pursued, and the results obtained.

By a joint resolution approved February 17, 1898, an invitation of the Government of Norway to take part in an international fisheries exposition, to be held at the city of Bergen, Norway, from May 16 to September 30, 1898, was accepted by this Government. The Commissioner of Fish and Fisheries was directed, in person, or by a deputy to be appointed by the President, to cause a suitable and proper exhibition and display to be made at this exposition of the food-fishes of the United States, and the methods of catching, salting, curing, and preserving them, and of the appliances used in carrying on the fishery industries of the United States. He was further authorized to use, with the consent of the Secretary of the Smithsonian Institution, any portion of the fisheries collection in the National Museum. In accordance with this resolution Capt. J. W. Collins, of Massachusetts, was designated to represent the United States at the exposition, and was duly appointed by the President on March 1, 1898. The work of collecting the necessary material for the exhibit was promptly begun, and on April 20 Captain Collins sailed for Norway. The scope of the exposition is designed to be very extensive in its illustration of the fishery industries, and, in accordance with law, at its close a full report will be submitted of the participation of the United States and of all information and results acquired by means of the exposition touching the fishery industries throughout the world.

FISHERIES CONGRESS.

On the invitation of the governor of Florida this Commission participated in the National Fisheries Congress, which convened in Tampa, Fla., to consider the propagation and protection of fish in the waters of the United States, and devise means and methods of protection for valuable food-fishes. The governors of the various States were requested to send delegates, and the convention, which was in session from January 19 to 24, was attended by many persons interested in the fisheries,

in fish-cultural work, and in scientific research. A number of papers on timely subjects were read and discussed, and it is believed that the personal meeting and interchange of views of those present will be of value to the fishery interests. This Commission was represented by Dr. Hugh M. Smith, Mr. W. de C. Ravenel, Mr. C. H. Townsend, Mr. H. F. Moore, and Lieut. Franklin Swift, of the steamer *Fish Hawk*.

As the *Fish Hawk* was on duty in neighboring waters she was directed to remain in Tampa Bay during the sessions of the congress and was visited by many of the delegates; the vessel was equipped with hatching apparatus and aquaria, in which some of the native fish and crustaceans of the region were shown, and an exhibition of the methods of deep-sea dredging was given in Tampa Bay. The Commission further participated by exhibiting collections of oysters, ornamental corals, and other products of American waters, and one of its fish transportation cars was also present. The proceedings of the congress and the papers there presented, covering a wide range of subjects, were published in the Bulletin for 1897 and also issued as a special document.

During March, 1898, an exhibition, given under the auspices of the New England Sportsmen's Association, was held in Boston, Mass., and at the request of citizens interested in the fisheries and in game, such assistance as was practicable in making the exhibit interesting and instructive was rendered by the Commission.

NEW STATIONS.

A final examination of the site selected for a fish-cultural station at Spearfish, S. Dak., was made during the summer of 1897, and as it was found that an ample supply of water would be available at all seasons the site described in the last annual report was decided on. The purchase of the land was consummated June 30, 1898, and the construction of the station will be prosecuted during the coming year.

During the summer and fall there was an investigation of the various localities in New Hampshire suggested as suitable for a fish-hatchery, and a selection was made of land near the Nashua River, about 1½ miles west of the city of Nashua. This site possesses in a greater degree than any others examined in the State the requisites for a fish-hatchery. An ample supply of water is obtainable from springs and artesian wells, and the topography of the land is such that it can be carried by gravity to the points where it will be used. The property is well suited for a favorable arrangement of buildings and ponds, and its proximity to a city of considerable size, with railroad facilities and a market for supplies, is of great advantage. The property was purchased March 28, 1898, and on May 12, 1898, the work of construction was begun.

At the new station at Erwin in Tennessee, the work has been continued, and a hatchery building, cottage for the superintendent, and other buildings have been completed. Ponds have been excavated, the water-supply lines and drains built, and necessary roads laid out. In November, although the work of construction was not complete, two

large ponds and six rearing-ponds were ready and the fish-cultural operations had begun.

On December 20, 1897, an act passed by the Virginia legislature was approved authorizing the transfer of the station at Wytheville from the State of Virginia to the United States. In accordance with an act of Congress approved June 8, 1896, the purchase was made March 5, 1898, and the preparation of plans for permanent improvements was begun. New buildings will be erected, the pond system enlarged, the water supply increased, and the efficiency of the station generally improved.

An item in the deficiency bill approved July 19, 1897, called for an investigation in the State of Georgia to select a suitable location for a fish-cultural station. A preliminary examination was made in the summer and fall of 1896 in the vicinity of Macon, as well as in other parts of the State. A number of localities were visited by agents of the Commission and a report was made to Congress January 5, 1898, showing that of all the sites examined, Cold Springs, near Bullochville, Meriwether County, is best adapted for the purpose required, having an abundant supply of clear, cold water, good railroad facilities, and land easily available for necessary constructions. Furthermore, the owner of the property is willing to donate the land to the Government for a fish-cultural station, as required by the act authorizing the survey.

On account of the importance of the blueback or sockeye salmon (*Oncorhynchus nerka*) in the Puget Sound region, the Commission has had under advisement the establishment of a hatchery for the propagation of that species at some point on the northwest coast. As extensive spawning-grounds of the blueback were known to exist at Baker Lake, Oregon, and as a hatchery had been successfully operated there by the State of Washington, a preliminary examination of the lake was made. It was found that an ample supply of eggs of the sockeye could be obtained and that the natural conditions of the locality were favorable.

At the request of citizens interested, an examination was made of the streams in the vicinity of Arkadelphia and Hot Springs, Ark., to determine on the advisability of establishing a hatchery, but no suitable location was found.

MISCELLANEOUS.

The new constructions and surveys mentioned above have been under the direction of the architect and engineer, Mr. H. von Bayer, who has continued the supervision of the repairs and alterations at the stations necessary to maintain their efficiency. Besides the routine work of this office, various charts, maps, and plans, to illustrate the reports of the Commission have been prepared there.

As there have been laws passed in many States requiring the erection of fishways wherever a dam is constructed, this office has been frequently called upon for advice, and plans and descriptions of fishways have been asked for. In order to be prepared to readily answer those

questions in future, Mr. von Bayer was directed to prepare a set of plans which combine the most important principles of fishways, and which can be easily adapted to the various constructions of dams. These plans, with directions for practical use, are completed and are ready for distribution to any State officer or other responsible person. A copy of this plan on a small scale is shown on plate III.

In addition to the regular duties of the naval engineer, he has prepared plans for new boilers for the steamer *Albatross*, and for the electrical and refrigerating apparatus at the Omaha Exhibition. Past Assistant Engineer C. W. Dyson, U. S. N., who has efficiently filled this position since October 21, 1895, was detached for regular naval duty April 26, 1898.

The distributing cars Nos. 1 and 3, having been in almost constant use fifteen years, showed the effects of continued service, and $10,000 having been appropriated, they were rebuilt and placed in thorough repair during the fall of 1898. They were supplied with modern equipment, and modifications suggested by experience were made in their arrangement and appliances, increasing their capacity and enhancing their strength and usefulness.

On account of the growth of the business of the Commission on the Pacific Coast and the consequent continued presence there of field agents and other employees, it became advisable to provide suitable office accommodations, as well as storage room for the material, which, in the form of collections, equipment, etc., had accumulated in considerable quantities. As no quarters were available in the Government Building in San Francisco, a room in the Academy of Sciences Building in that city was engaged at nominal cost, and has been of value in the convenient and prompt transaction of business in the West, especially in the preparation and distribution of reports relating particularly to the Pacific States.

During the year the bound reports, with appendices, for the fiscal years 1896 and 1897 and the following pamphlets were issued:

Report of the Commissioner for the fiscal year ending June 30, 1897, by John J. Brice. (Report for 1897, pp. I–CLXXI.)

A manual of fish-culture, based on the methods of the United States Commission of Fish and Fisheries, with chapters on the cultivation of oysters and frogs, prepared under the direction of John J. Brice, Commissioner. (Report for 1897, pp. 1–340.)

Artificial propagation of the Atlantic salmon, rainbow trout, and brook trout. (Report for 1897, pp. 27–101.)

Artificial propagation of the black bass, crappies, and rock bass. (Report for 1897, pp. 159–177.)

Notes on the edible frogs of the United States and their artificial propagation, by F. M. Chamberlain. (Report for 1897, pp. 249–261.)

Oysters and methods of oyster-culture, with notes on clam-culture, by H. F. Moore. (Report for 1897, pp. 263–340.)

The fishes of the Klamath River Basin, by C. H. Gilbert. (Bulletin 1897, pp. 1–13.)

A report upon salmon investigations in the Columbia River Basin and elsewhere on the Pacific coast in 1896, by Barton W. Evermann and Seth Eugene Meek. (Bulletin 1897, pp. 15–84.)

The fishes found in the vicinity of Woods Hole, by Hugh M. Smith. (Bulletin 1897, pp. 85–111.)

Publications of the United States Commission of Fish and Fisheries available for distribution on June 30, 1897. (Report for 1896, pp. 313–356.)

Report of observations made on board the United States Fish Commission steamer *Albatross* during the year ending June 30, 1896. (Report for 1896, pp. 357–386.)

Observations upon the herring and herring fisheries of the Northeast coast, with special reference to the vicinity of Passamaquoddy Bay, by H. F. Moore, Ph. D. (Report for 1896, pp. 387–442.)

The salmon fishery of Penobscot Bay and River in 1895 and 1896, by Hugh M. Smith. (Bulletin 1897, pp. 113–124.)

Descriptions of new or little-known genera and species of fishes from the United States, by Barton W. Evermann and William C. Kendall. (Bulletin 1897, pp. 125–133.)

Notes on the halibut fishery of the Northwest coast in 1896, by A. B. Alexander. (Bulletin 1897, pp. 141–144.)

The herring industry of the Passamaquoddy region, Maine, by Ansley Hall. (Report for 1896, pp. 443–487.)

Statistics of the fisheries of the interior waters of the United States, by Hugh M. Smith. (Report for 1896, pp. 489–574.)

Notes on the fisheries of the Pacific coast in 1895, by William A. Wilcox. (Report for 1896, pp. 575–659.)

There have been distributed 4,460 bound and 12,420 pamphlet copies of the publications of this Commission.

The Museum of Comparative Zoology has continued the publication of the series of papers based on the material collected during the investigations of the United States Fish Commission steamer *Albatross*, in 1891, and during the year has issued the following:

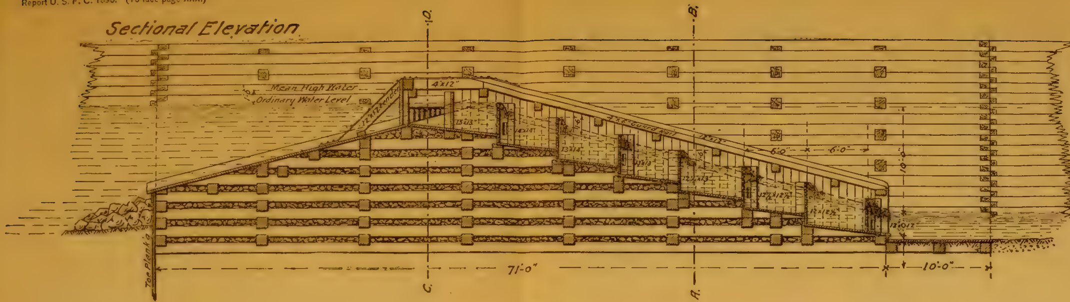
Memoirs, vol. XXIII, No. 1—XXI, Die Medusen; by Otto Maas.
Bulletin, vol. XXXI, No. 5—XXII, The Isopoda; by H. J. Hansen.
Bulletin, vol. XXXII, No. 5—XXIII, Preliminary report on the Echini, by Alexander Agassiz.

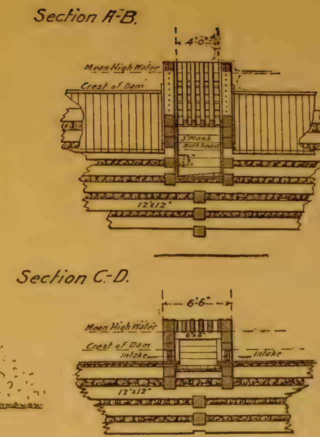
Appropriations were made by Congress for the operations of the Commission for the fiscal year ending June 30, 1898, as follows:

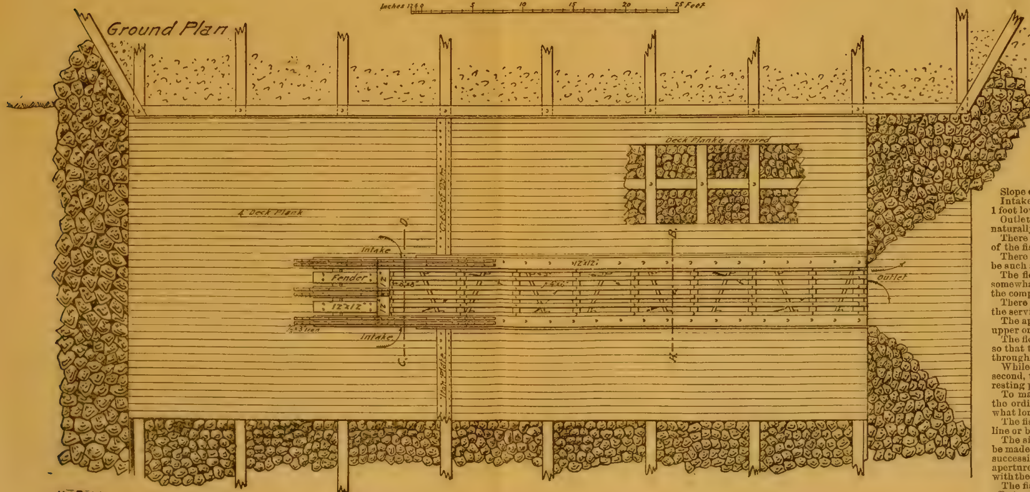
Salaries	$195,620.00
Miscellaneous expenses:	
Administration	9,000.00
Propagation of food-fishes	132,500.00
Maintenance of vessels	30,500.00
Inquiry respecting food-fishes	10,800.00
Statistical inquiry	5,000.00
For new boilers and general repairs to the steamer *Fish Hawk*	29,640.00
For rebuilding steam launch in use on Potomac River	2,000.00
For purchase of steamer *Senator* for station at Green Lake, Me	1,500.00
For purchase of steam launch for steamer *Albatross*	4,000.00
For rebuilding fish-transportation cars	10,000.00
For establishment of fish-cultural station in New Hampshire	15,000.00
For establishment of fish-cultural station at Battle Creek, Cal	3,500.00
For construction of dwelling-house at the station at St. Johnsbury, Vt.	3,500.00
For additional water supply at the station at St. Johnsbury, Vt	3,000.00
For completion of stations now under construction at—	
San Marcos, Tex	1,800.00
Manchester, Iowa	4,216.50
For investigation and selection of site for a fish-cultural station in Georgia	500.00

A report showing in detail the expenditure of these appropriations will be made to Congress in accordance with law.

GEO. M. BOWERS,
U. S. Commissioner of Fish and Fisheries.







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DIRECTIONS.

Slope of fishway should not be steeper than on a ratio of 1 vertical to 4 horizontal.

Intake, or up-stream end of fishway, should be amply large and placed not less than 1 foot lower than crest of dam.

Outlet should be below low-water level and so located or constructed that fish are naturally led to it when ascending the stream.

There should be relatively deep water, with an unobstructed flow below the outlet of the fishway. An ample discharge of water should attract the fish to the outlet.

There should be plenty of light admitted in the fishway, and its construction should be such as to be readily inspected and cleaned of any débris lodging therein.

The floor of the compartments should be laid slightly inclined and the bulkheads somewhat obliquely across the fishway, so that the current of water passing through the compartments can more readily clear the same of sand, gravel, mud, and rubbish.

There should be no regulating gates or other devices at the intake which necessitate the services of an attendant.

The apertures in the bulkheads should increase progressively from the lower to the upper ones, to insure overflow from compartment to compartment.

The flow of water should be abundant, forming small waterfalls over the bulkheads, so that the fish may either jump from one compartment to the next above or may dart through the apertures in the bulkheads.

While the flow of water through the apertures may reach a velocity of 10 feet per second, there will be relatively quiet water in the compartments, thus furnishing a resting place for the ascending fish.

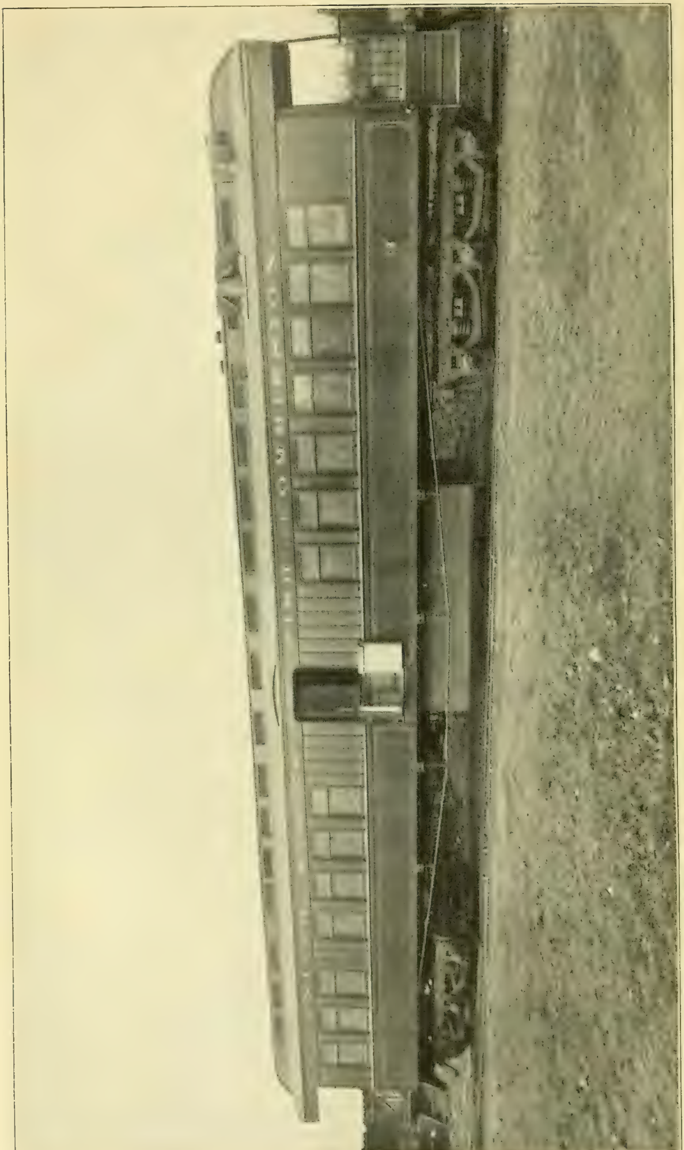
To maintain the operation of the fishway at an average high water the same as at the ordinary stage of the stream or river, the uppermost compartment is made somewhat longer, and a central bulkhead is inserted having its crest at high-water level.

The fishway may be constructed of wood or masonry and iron; it may follow a straight line or be built in angles and curves, as the local conditions may require.

The size of the fishway depends principally on the volume of water available, and can be made larger or smaller than that shown on plan. The hydraulic head between two successive compartments must be so chosen as to obtain a current velocity through the apertures of not to exceed 10 feet per second. At low-water stage of the stream or river, with the fishway flowing full, there should be a liberal discharge over the crest of the dam.

The fishway should be built very strong and be well protected against the destructive effects of freshets, drift ice, etc.

FISHWAY—IMPROVED CAIL SYSTEM.



CAR NO. 3—EXTERIOR.

REPORT ON THE PROPAGATION AND DISTRIBUTION OF FOOD-FISHES.

By W. DE C. RAVENEL, *Assistant in Charge.*

INTRODUCTION.

The operations of the Division of Fish-culture during the fiscal year were more extensive and important than ever before. The number of eggs, fry, and adult fish distributed was 857,509,546, the majority of which represent the important commercial species, such as the cod, shad, whitefish, quinnat salmon, lake trout, herring, pike perch, and lobsters.

Following the general lines adopted the previous year, the propagation of the quinnat salmon, the most important of the Pacific coast fishes, was conducted not only at Battle Creek and Baird, in the Sacramento River Valley, and on the Clackamas, Salmon, and Little White Salmon rivers, tributaries of the Columbia, but a temporary station was established and operated on the Rogue River and the hatchery on the Siuslaw River was reopened. Arrangements were also perfected to collect salmon eggs at the headwaters of the Clackamas River, where the spawning-beds of the early run of fish entering that stream in April and May are found. The results at the Battle Creek and Little White Salmon stations were even better than had been anticipated, over 62,000,000 eggs being taken at the two points. The fish resulting from the collections made at all of the stations were liberated in streams on the Pacific coast, with the exception of 6,000,000, which were transferred to eastern stations to continue the experiment of acclimatizing the quinnat salmon in the coastal streams of the Atlantic Ocean.

Encouraged by reports of the capture of steelhead trout in tributaries of the Great Lakes, as a result of plants made by this Commission two years ago, 750,000 eggs of this species were sent to stations on the lakes and in New England for deposit in suitable waters.

Some experimental work was undertaken at Put-in Bay in penning and holding adult whitefish until ready to deposit their eggs, with the view to increasing the collections on Lake Erie, so as to supply the hatcheries at Duluth, Alpena, and Cape Vincent. The results, though not large, show that by similar methods good returns may be expected, and under favorable conditions the number of eggs collected in the future will be limited only by the number of whitefish taken during the fall months, whereas, under the present system, a storm occurring during the short spawning season reduces the collections from 30 to 50

per cent. The expansion of this work on Lake Erie is essential if the hatcheries on the Upper Lakes are to be kept open, as the collection of eggs on Lakes Huron and Michigan is now impracticable on account of the recent act passed by the Michigan legislature forbidding the capture of whitefish from November 1 to December 15, which covers almost the entire spawning period of that species. For the reason stated above, the whitefish and lake-herring work was confined to Put-in Bay Station.

The collection of lake-trout eggs at Duluth and Northville was larger than usual, notwithstanding the fact that the passage of the act referred to above prevented the collection of eggs at many of the most important fishing points on Lake Michigan. The field of operations was extended into Georgian Bay, where large numbers of eggs were secured, and to the eastern end of Lake Superior, where the fishermen had heretofore furnished eggs to the Michigan Fish Commission.

The resumption of pike-perch work on Lake Erie, after a lapse of two years, resulted in the collection of 221,000,000 eggs and the liberation of 81,153,000 fry in the waters of Lakes Erie and Ontario.

The propagation of marine species was commenced early in the fall at Woods Hole and Gloucester, Mass., on the plan heretofore followed, except that an additional field station for the collection of cod eggs was established at Plymouth, Mass., and the number of brood-fish held at Woods Hole Station was materially reduced. The results attained by these changes were exceedingly satisfactory, over 300,000,000 eggs being handled at the two stations, which resulted in the liberation of 203,000,000 fry on the spawning-grounds along the New England coast.

Considerable attention was also paid to the propagation of flatfish during the months of February and March, but, owing to presence of ice until after the spawning season was partially over in Waquoit Bay, the number of eggs collected was not so large as had been anticipated.

Notwithstanding the decline in the lobster fishery and other unfavorable conditions, over 60,000,000 eggs were taken on the coasts of Maine and Massachusetts north of Cape Cod. South of the cape and along the coasts of Connecticut and Rhode Island, however, the results were unsatisfactory, due not only to a decided decrease in the fishery, but to the fact that little or no fishing was being done in the vicinity of Woods Hole Station, where large numbers of eggs are ordinarily collected. This was partly attributed to the passage of a law by the State of Massachusetts forbidding pound or trap-net fishing in Buzzards Bay, from which source all of the bait used by the lobster fishermen had been derived.

The shad work was the largest ever accomplished by the Commission, more than 300,000,000 eggs being taken on the Susquehanna, Delaware, and Potomac rivers and Albemarle Sound. The steamer *Fish Hawk*, detailed during the winter for shad work in southern waters, was used as a floating hatchery at Avoca, N. C., on the Chowan River, at the head of Albemarle Sound. Previous to commencing this work she

was employed in making an investigation of the Edisto River, South Carolina, to determine the advisability of establishing an auxiliary station for the propagation of shad on that stream, but the information gained was not favorable.

Operations on the Delaware and Potomac rivers were materially interfered with by causes pertaining to the war with Spain; on the Delaware by the withdrawal of the *Fish Hawk* for naval duty at the very height of the spawning season, and on the Potomac by the establishment of a blockade at Fort Washington and by the laying of mines or torpedoes on the spawning-grounds.

In order that the shad work on the Delaware might not be omitted altogether, arrangements were made with the Pennsylvania Fish Commission for the use of their shad-hatchery at Bristol, which permitted the hatching and planting of 21,000,000 fry in this stream and its tributaries. At Battery Station, on the Susquehanna, the results were very satisfactory, over 209,000,000 eggs being secured between April 13 and June 10, about 100 per cent more than had ever been taken at any of the stations of the Commission during a single season.

At the trout and bass stations the work was generally satisfactory, the production of brook trout being much larger than ever before. The number of bass distributed was small as compared with other fishes, but it is believed, with the experience gained during the past season, that the output from the various stations will be largely increased next season. Considerable attention has also been paid to the propagation of the crappie, one of the most desirable fishes for stocking the streams and lakes in the Mississippi and Missouri River valleys, and in the South and Southwest.

In addition to the fishes heretofore handled, the propagation of the Montana grayling was taken up at Bozeman Station; about 3,000,000 eggs were collected at Red Rock, Montana, at the headwaters of the Jefferson River. Efforts have been made in past years by the United States Fish Commission and the various State fish commissions to collect eggs of this valuable game and food fish, but the results heretofore attained have been very unsatisfactory.

Continuing the experiments of previous years, two consignments of adult lobsters were sent from Woods Hole to San Francisco during the months of July and December and liberated near the Farallone Islands. Of these, 229 were females, carrying from 10,000 to 25,000 eggs each, so that it is estimated that from 3,000,000 to 4,000,000 young lobsters resulted from this plant, in addition to the adults.

In July a carload of tautog and blue crabs was also sent west for introduction into the waters of the Pacific, as it was thought they would not only be well adapted to the waters of the Pacific Coast, but would prove valuable additions to the fishery resources of that section. The plants were made near the Farallone Islands during July, and consisted of 566 fish ranging in length from 4 to 10 inches, and 162 of the common blue crab of the Atlantic Coast.

SPECIAL INVESTIGATIONS AND INSPECTION.

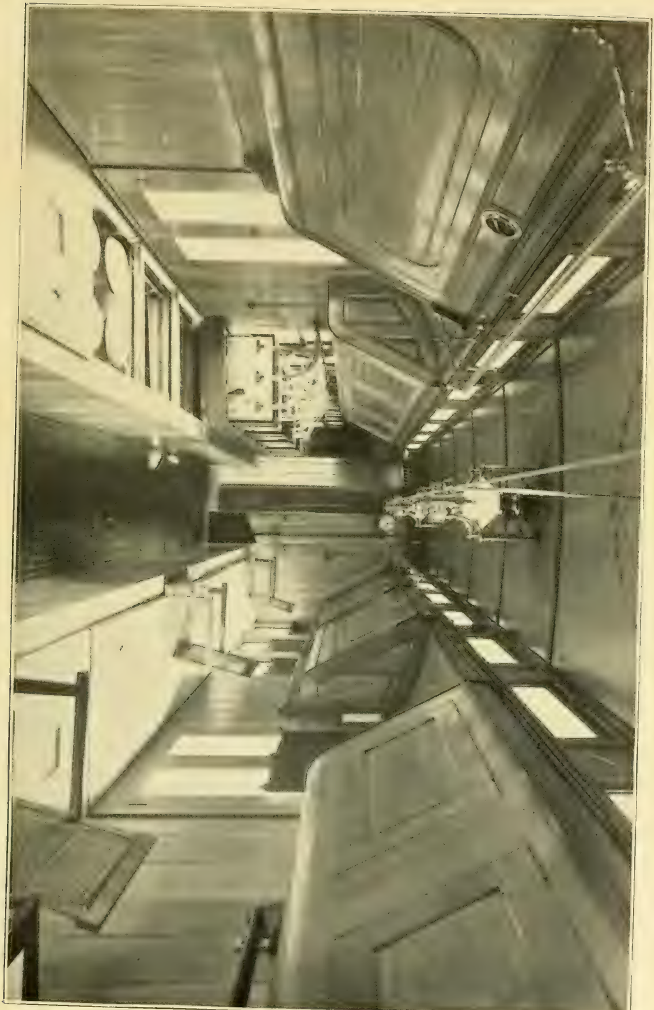
During the month of August the assistant in charge inspected the stations of the Commission in Michigan, Minnesota, Montana, Colorado, Missouri, and Illinois. Advantage was taken of the opportunity to confer with the superintendents regarding the conduct of the work and the possibilities of its extension. The general condition of affairs at all of the stations was satisfactory, and discipline, on the whole, was found to be well maintained. The buildings and grounds at most of the stations were in only fair condition, and in order to maintain and render them attractive to the public special appropriations are needed for most of them, as indicated in recommendations submitted with detailed report of inspection. An appropriation for improvements at the Leadville Station is particularly important, as an additional supply of water is needed, and in order to obtain the best results it will be necessary to provide some system for draining the Evergreen Lakes during the fall, so as to handle the brood-fish. The buildings at this station are in excellent condition, but the grounds are overgrown with brush and prairie grass, and as it is quite a popular resort for the residents of Leadville, it should be completed. This could be done at comparatively small expense. The general condition of the station at Neosho, Mo., was worse than any of the others. The ponds were much in need of repair, and the water supply is inadequate.

In December a preliminary survey of the Edisto River, South Carolina, was made to determine as to the practicability of establishing an auxiliary station for the propagation of shad, and as a result the *Fish Hawk* was detailed in March to visit that stream and undertake the collection of eggs. During April several trips were made to the shad stations on the Potomac and Susquehanna rivers, and in May to the Delaware River, for the purpose of conferring with Mr. W. E. Meehan, of the Pennsylvania Fish Commission, and the commanding officer of the steamer *Fish Hawk*, relative to conduct of shad work at the Bristol hatchery in the event of the *Fish Hawk* not being available for work in this vicinity. Visits were also made in May to Massachusetts, to arrange for lobster collections at Gloucester and Woods Hole.

During the spring of 1898 the superintendent of the Cape Vincent Station investigated the sturgeon fisheries of Lakes Erie and Ontario with the view to taking up the propagation of this species, but no locality was found where spawning fish could be obtained in sufficient numbers to warrant the establishment of an auxiliary station for this purpose.

CAR AND MESSENGER SERVICE.

Owing to the necessity for rebuilding cars Nos. 1 and 2 and the large amount of routine work necessitated by the increased output of fish during the fiscal year, this service has been taxed to its utmost capacity, and it was found necessary to hire baggage and express cars from the railroads on several occasions to assist in making the distribution in Virginia and Michigan. Besides the routine work, one of the



CAR NO. 3—INTERIOR.

cars was used during the first four months of the fiscal year in making collections of marine and fresh-water fishes and transporting the same to the Tennessee Centennial Exposition at Nashville, Tenn., and again during the months of May and June, 1898, in transferring salt-water specimens from Woods Hole, Mass., to Omaha, and fresh-water fishes from Quincy, Ill., and other points in the Mississippi Valley.

Car No. 3 also made two trips from Woods Hole to San Francisco with lobsters, tautogs, and blue crabs, the first in July and the last in December. On the return trip of the car in July 350 giant crabs were brought from the Pacific Coast and planted in Pagan Creek, a tributary of the Chesapeake Bay. The car left San Francisco July 31 with 1,100 crabs, 600 females and 500 males; 450 were packed in seaweed in the refrigerator compartment under the car, 550 were placed in transportation tanks, in salt water with air circulation, and 100 in crates packed in grass. On August 1, when the crabs were overhauled, all were dead except those in tanks of aerated water; up to this time the temperature had been maintained at 60°; 36 were lost on August 2, 45 on the 3d, 58 on the 4th, and 61 on the 5th; the temperature had risen from 60° to 65°, the average for the period being 62°. Of 350 crabs reaching Newport, Va., 200 were females and 150 males. These were planted, with the cooperation of the officials of the Chesapeake and Ohio Railroad, in Pagan Creek, Isle of Wight County, Virginia. The temperature of the water in which they were liberated was 78°.

Excellent results were attained on the last trip, in December, over 90 per cent of the lobsters reaching the Pacific Coast alive. On previous trips the number reaching the destination in good condition never exceeded 50 per cent, and several times it was as low as 30 per cent. This difference in results is attributed not only to the fact that the trip was made at a season when a low temperature could be maintained, but also to the difference in the methods of transportation. On November 29 the car left Woods Hole with 150 egg-lobsters, packed 5 in a crate, with seaweed. At Boston 98 egg-lobsters and 50 males were taken on and placed in 50-gallon transportation tanks filled with filtered water and constantly supplied with air, 30 being placed in each tank. Those in the crates were taken out every day and dipped into the tanks of salt water and then repacked, the seaweed being sprinkled with salt water twice a day. The loss from December 1 to 5, when the car reached San Francisco, was 27. The average temperature of the water en route was 45°, maximum 50°, and minimum 36°.

The methods followed in handling the fish were practically the same as before, except in the case of the lobsters.

The cars traveled during the year 98,964 miles, of which 63,167 miles were free; detached messengers traveled 121,160 miles, of which 33,346 were free. Every State and Territory in the Union was visited. No accidents of any importance occurred, and the losses of fish were about the same as usual, less than 2 per cent of the total number handled, including the marine species, where the losses usually vary from 40 to 70 per cent on long trips.

On the return of car No. 3 from its last trip to the Pacific Coast it was sent to Tampa, Fla., to remain during the sessions of the Fisheries Congress, from January 19 to 26, for the purpose of illustrating the methods employed in hatching eggs and distributing fishes.

In July car No. 1 was placed in the shops of Jackson & Sharp, and in August car No. 3 in the shops of Harlan & Hollingsworth, Wilmington, Del., and were rebuilt at an expense of about $11,000. They were remodeled on practically the same plan, except that the center doors of car No. 1 do not extend to the floor, as is the case in car No. 3.

The dimensions of car No. 3 as rebuilt are as follows: Length of body, 60 feet; total length from end of platform to end of platform, 67 feet 10 inches; width, 9½ feet; height from top of rail to top of roof, 13 feet 8 inches. The frame of the car is so braced as to permit of the two large doors in the center extending from floor to roof, as shown in plate IV. This feature very materially simplifies loading and unloading. The interior of the car is finished in ash, and in one end is an office, an ice-box of 1½ tons capacity, and a pressure tank holding 500 gallons of water; at the other end are the boiler room and kitchen. The boiler room is equipped with a 5-horsepower boiler, circulating water pump, and air and feed pump. The tanks and cans used in transporting fish are carried in two compartments running along the sides of the car between the office and boiler room. They are 30 feet long, 3 feet wide, and 25 inches deep. Under the car, between the trucks, is a reservoir tank holding 600 gallons of water, and from which water is pumped into the pressure tank near the office; it then passes from this tank to the fish cans and tanks, and then back to the reservoir. In the middle of the car, over the compartments referred to, are four berths and several lockers for the use of the crew. The office also contains two berths, a writing desk, and a typewriter. These cars are fully equipped with all modern improvements in the way of brakes, couplers, signal whistles, etc., and have Pullman trucks and 33-inch Allen paper wheels. With the large water capacity provided, they are capable of carrying much greater loads of fish than ever before.

EXPOSITIONS.

The Tennessee Centennial Exposition, in progress at Nashville at the close of the fiscal year, was terminated October 31, and all material except the aquaria was returned to Washington. During July and August much difficulty was experienced in keeping up the display of fishes in the aquarium on account of the intense heat. During June the temperature of the salt water rose rapidly, and when it reached 78° it became necessary to adopt artificial means to save the fish, notwithstanding the fact that the specimens exhibited were all collected in southern waters, at Morehead City, N. C., and Pensacola, Fla. This was accomplished by passing all the water used through 300 feet of pipe coil, packed in crushed ice and salt. This method proved very expensive, as it required over 1½ tons of ice per day to reduce the temperature below the danger point, that is, 70°.

MAIN ENTRANCE TO AQUARIUM, OMAHA.

Notwithstanding the unfavorable conditions the aquaria were kept fully supplied with most of the commercial fishes of the Gulf and the South Atlantic Ocean, with many of the ornamental species and all of the fishes of the Mississippi Valley, and with a number of *Salmonidæ* propagated by the Commission, such as the brook trout, rainbow trout, steelhead, and quinnat salmon. In September fish-cultural work was taken up, and two consignments of 10,000 salmon eggs shipped from California were hatched. This feature of the exhibit was particularly interesting to the people of that section of the country, as it was the first time that the eggs of any of the *Salmonidæ* had been artificially hatched in Tennessee. This was only rendered possible by the sinking of a well near the Government building, which furnished a steady flow of excellent water at 59° throughout the summer. At the close of the exposition the fishes on hand were planted in suitable waters in the vicinity or transferred to some of the stations of the Commission. The aquaria material, including the machinery, was shipped to Omaha. During the absence of the representative from Nashville the exhibit was at different times under the direction of L. G. Harron, W. P. Sauerhoff, and R. J. Conway. Mr. Conway was in charge at the close of the exposition and attended to the packing and shipping of the exhibit. A report of the part taken by the U. S. Fish Commission in this exposition will be found on pages 329–339 of the appendices to this report.

On July 27 the assistant in charge of the Division of Fish-culture was appointed representative of the United States Fish Commission on the government board of management for the Trans-Mississippi and International Exposition, to be held in the city of Omaha, Nebr., in accordance with act approved June 4, 1897. The board was not organized until September, when the allotment of funds and space was made, the Commission receiving $20,000 and 5,027 square feet of space in the northwest corner of the Government Building. Subsequently all allotments were changed, owing to the passage of a joint resolution by the House and Senate on December 18, the appropriation from the Government exhibit being reduced from $150,000 to $137,500, so that the amount available for the Fish Commission was $18,333.

As the live-fish exhibit at previous expositions had proved the most attractive feature, it was decided to devote $10,000 and 4,000 feet of space to the erection of a suitable aquarium. The plans and specifications for this were prepared by Mr. George A. Schneider, who also superintended its construction.

The aquarium is a grotto-like structure, 140 feet long by 26 feet wide, arranged in the shape of a $\sqcup$ with arched entrances at the short arms and a rotunda at the turning points. The entrances are semi-circular archways supported on colonnades, embellished with ornamental work, soffit and face, and flanked on each side by wings in a rich pilaster treatment of the renaissance style. An ornamental, semi-circular grille, with the seals of the United States and the State of Nebraska, is inserted in the arch, the top of which terminates in

imitation shellwork, with a youthful Poseidon taming an aquatic monster, over the keystone.

Surmounting the entablature of the wings are two allegorical figures representing fisher-maids catching and planting fish in the waters of the country. The exterior portions of the entrances are finished in imitation ivory and gold. The interior of the grotto is treated in imitation of a roughly blasted rock tunnel, and depending from its roof are numerous stalactites of a pale-greenish hue. The aquaria, of which there are 25, are each 7 feet long, 3 feet high, and 5 feet wide at the top; they extend along the sides of the interior of the grotto, and are decorated inside with rock and aquatic plants, and arranged so that all light entering the grotto first passes through them. Eight of them are used for showing such salt-water fishes as can be obtained off the New England coast near Woods Hole, Mass., and the balance are filled with species indigenous to the Mississippi River and the various fishes propagated by the Commission. In each of the rotundas are large, oval pools so arranged as to be illuminated from below with electric lights.

In the rectangular space formed by the two short arms of the grotto are exhibits of the different phases of the work of the Commission. The methods employed by the Commission in fish-cultural work are practically demonstrated by hatching, in a regulation trough, rainbow and black-spotted trout eggs, shipped by express from Colorado during the month of June. As it is impracticable to secure semi-buoyant eggs, such as shad, whitefish, and pike perch, and floating eggs like the cod, pollock, and flatfish, the methods are illustrated with artificial eggs made of rosin. In addition to practical illustrations, models of the various forms of apparatus used are exhibited, including a model of the trout station at Leadville, Colo. The process of egg-taking is shown by a lay figure of a spawn-taker with a quinnat salmon in his hands in the act of stripping the eggs. The work of distribution is illustrated by photographs, drawings, and a working model of car No. 3, recently reconstructed by Harlan & Hollingsworth. The results of fish-culture and the scope of the work accomplished by the Commission during the fiscal year 1896–97 are shown by large charts and numbers of photographs and drawings.

The scientific functions and work of the Commission are set forth by models and photographs of the exploring vessels *Albatross* and *Fish Hawk*, by an assortment of seines, dredges, nets, and by the deep-sea sounding apparatus used in making collections in fresh and salt water. In this section there is also a full collection of oyster shells, illustrating their sizes at different ages, peculiarities common to various regions, materials used for the attachment of spat, various objects to which young oysters adhere, influence of the bottom on the oyster's growth, and enemies and injuries caused by each. Among the objects of the American fisheries exhibited are the following: Mounted groups of northern fur-seals, Steller's sea lions, casts of cetaceans, 150 casts of food-fishes colored from living or fresh specimens, and painted casts of edible frogs.

GENERAL VIEW OF THE FISH COMMISSION EXHIBIT, OMAHA.

Through the courtesy of Messrs. Tiffany & Company, of New York, a collection of pearls and pearl-bearing mollusks is shown, consisting of specimens of white, pink, brown, copper-colored and fancy-colored pearls, a set of pearl-bearing shells, instruments for opening them, also a water-telescope for finding the mollusks, and illustrations of pearls.

In the fisheries section the various forms of nets, traps, weirs, pound nets, seines, pots, dredges, tongs, etc., used in the capture of fresh-water products are fully shown, also characteristic types of fishing craft employed in the American fisheries, among them the swift New England schooner, the Florida smacker, the Chesapeake Bay oyster pungy, the shad boat of the North Carolina sounds, and the San Francisco market steamer. In addition to these are numerous large photographs, portraying the methods adopted in the important commercial fisheries of the Atlantic, Gulf, and Pacific coasts and the Great Lakes, and a series of crayon pictures illustrating the Alaskan fur-seal fishery. The fisheries of the United States are presented by States on a large chart.

At the opening of the exposition the aquarium contained a large variety of fresh-water and salt-water fishes, together with a number of aquatic invertebrates. The fresh-water fishes comprise brook trout, rainbow trout, black-spotted trout, yellow-fin trout, lake trout, steelhead trout, large-mouth and small-mouth black bass, crappie, strawberry bass, sunfishes, and the characteristic native fishes of the Mississippi Valley, including the largest obtainable specimens of sturgeon, catfish, and paddlefish, several of the catfish weighing 40 pounds and over. Aquatic reptiles are represented by living specimens of mud puppies, terrapin, edible frogs, etc. These large specimens, with a number of ornamental species like goldfish, tench, and golden ide, are displayed in oval pools under the rotundas and prove a most attractive feature. In the salt water tanks about 50 varieties of food, game, and bait fishes of the Atlantic coast are represented by specimens of various ages, including dogfish, skates, sea bass, kingfish, tautog, chogset, sculpin, scup, toadfish, sea robin, pollock, cod, hake, and flounders. Lobsters, crayfish, crabs, and various kinds of mollusks are also exhibited.

As it was impracticable for the representative to remain in Omaha after the opening of the exposition, the Commission is represented by Mr. R. J. Conway, who has charge of the aquarium, and by Mr. W. P. Sauerhoff. Mr. L. G. Harron was detailed from Washington to assist in the installation of the aquarium, and rendered effective service during the opening days of the exposition.

The Commission is much indebted to the Union Tank Line Company, of New York, for the loan of two tank cars for transporting salt water from Woods Hole, Mass., to Omaha; also to the Michigan Central and the Chicago, Milwaukee and St. Paul railroad companies for free transportation, and to the Michigan Central Railroad for the transportation of car No. 4 with salt-water fishes over its line, and to the Missouri Pacific for transporting all the cars of the Commission into the exposition grounds.

STATION OPERATIONS.

The fish-cultural work of the several stations is given in detail in the abstracts from the reports of the superintendents, and embraces the propagation of 26 species of fish and 1 crustacean. The following stations and auxiliary stations were operated during the year:

Green Lake, Maine.
Craig Brook, Maine.
Grand Lake Stream, Maine.
St. Johnsbury, Vermont.
Cape Vincent, New York.
Gloucester, Massachusetts.
Woods Hole, Massachusetts.
Steamer *Fish Hawk* (Albemarle Sound, Edisto River, Delaware River).
Bristol, Pennsylvania.
Battery Station, Maryland.
Bryan Point, Maryland.
Central Station, Washington, D. C.
Fish Ponds, Washington, D. C.
Wytheville, Virginia.
Erwin, Tennessee.
Put-in Bay, Ohio.
Northville, Michigan.
Alpena, Michigan.
Duluth, Minnesota.
Manchester, Iowa.
Quincy, Illinois.
Neosho, Missouri.
San Marcos, Texas.
Leadville, Colorado.
Bozeman, Montana.
Baird, California.
Battle Creek, California.
Fort Gaston, California.
Clackamas, Oregon.
Upper Clackamas, Oregon.
Salmon River, Oregon.
Rogue River, Oregon.
Siuslaw River, Oregon.
Little White Salmon River, Washington.

Green Lake Station, Maine (E. E. Race, Superintendent).

During the summer, various minor improvements and repairs to buildings and ponds were made by the station force, including the painting of the hatching and collecting apparatus; a nursery containing 40 troughs was built in the rear of the hatchery, arranged so that the surplus water can be utilized for the rearing-ponds. An orchard was set out between the superintendent's cottage and the hatchery. At the beginning of the fiscal year the stock on hand was as follows:

Species.	Calendar year in which fish were hatched.		
	1897.	1896.	1891.
Landlocked salmon	131,141	434	471
Brook trout	116,122		
Golden trout	22,136		
Steelhead trout	9,335		
Atlantic salmon	16,220		

Owing to an unprecedented rise in temperature early in July, it became necessary to dispose of the brook and golden trout, and they were planted in the tributaries of Green Lake. The balance of the fish were retained until early fall and distributed as usual to applicants in the New England States. No mortality from disease occurred during the season, but from July 7 to 15 the losses from heat were quite heavy, the temperature during that period reaching 81° in the troughs and 83° in the ponds.

In August arrangements were made for collecting eggs of the landlocked salmon, brook trout, and golden trout at Winkempaugh Brook (Branch Pond), Patton Pond, Flood Pond, Green Lake, and its tributaries. Steps were also taken to collect eggs of the lake trout (togue) and landlocked salmon in Cold Stream Pond, near Enfield. The traps

INTERIOR OF THE GROTTO, LOOKING FROM ONE THE POOLS, OMAHA.

and pens were put in place during August and September, and the first trout were captured in the latter month. At Cold Stream Pond the lake trout made their appearance on the spawning-grounds October 8, and the run continued until the 19th.

The following table shows the number of fish captured at the various field stations and eggs secured:

Point of collection.	Species.	Fish.	Eggs.
Winkempaugh Brook	Brook trout	206	207,000
	Landlocked salmon	59	182,000
Patton Pond	Brook trout	70	105,000
	Landlocked salmon	3	3,500
Flood Pond	Brook trout	59	28,000
	Landlocked salmon	2	....
	Golden trout	146	83,500
Green Lake	Brook trout	21	18,200
	Landlocked salmon	127	273,000
Cold Stream Pond	Lake trout (togue)	75	150,000
	Landlocked salmon	44	100,000

The number of eggs secured exceeded the collections of past seasons, 558,500 landlocked salmon eggs being obtained from 235 adults, an average of over 2,000 per fish. At the close of the spawning season the fish were all liberated, without loss, in the waters from which they were taken. The results attained at Enfield were particularly gratifying, considering that operations were undertaken at that point late in the season. It is expected that over 1,000,000 togue eggs will be collected there another season, as the fish are abundant and easily captured. Of the 150,000 eggs secured, 75,000 were left at Enfield in charge of Mr. E. J. Darling, superintendent of the State hatchery, to be hatched and liberated in the waters from which they were derived. The brook-trout and landlocked-salmon eggs collected at Flood Pond, Winkempaugh Brook, and Patton Pond were hauled to the station by wagon over rough country roads immediately after fertilization and suffered a loss during incubation of from 8 to 14 per cent, whereas the loss on the eggs collected from fish captured in Green Lake and penned at Great Brook (about ¼ mile from the hatchery) was only 3½ per cent.

During the late fall and early winter 126,243 landlocked-salmon eggs, 25,000 brook-trout eggs, and 10,000 golden-trout eggs were shipped to various State fish commissions, private applicants, and other stations of the Commission. The balance of the eggs were held at the station to be hatched and liberated as fry and yearlings. The fry commenced hatching on January 4 and by April 30 were all out. In view of the heavy mortality experienced during the previous July it was decided to abandon all efforts to carry the brook and golden trout during the summer; 225,000 of the former and 59,144 of the latter were distributed during May and June.

On December 24 a consignment of 1,000,000 salmon eggs was received from Battle Creek, Cal., in excellent condition, only 7,270 having died en route; 50,000 of these were turned over to the State of Maine and the balance were distributed, immediately after the absorption of the sac, in Union River and its tributaries during the month of May.

Of the 50,000 steelhead-trout eggs received from Fort Gaston, Cal., in March, 22,966 fry were planted in Green Lake and other waters in the vicinity during the spring.

All the Atlantic salmon on hand at the beginning of the year were held until March 30, when they were liberated in Green Lake, with a loss of only 12. With the exception of 50 specimens, all of the domesticated salmon hatched in 1891 were planted in Green Lake during the fall, as the ponds occupied by them were needed for other fishes. A few thousand eggs were collected from the 50 referred to, but they died in less than forty-eight hours after being placed in the troughs. At the close of the year there remained on hand the following:

Species.	Calendar year in which hatched.	
	1897.	1896.
Landlocked salmon	336,936	279
Brook trout	13,831	....
Steelhead trout	8,830	3,370

CRAIG BROOK STATION, MAINE (CHARLES G. ATKINS, SUPERINTENDENT).

The stock on hand July 1, 1897, consisted of 471,294 fish hatched the previous winter, chiefly Atlantic and quinnat salmon, a few landlocked salmon, steelhead, and Scotch sea trout; also 2,464 adults, varying in age from 2 to 6 years. All of the fry hatched the previous spring were held during the sac and early feeding stages in the standard troughs used at the station. They were supplied with water obtained from Craig Brook, its temperature during June ranging from 50° to 67°. Press of other work delayed the transfer of these fish to the ponds until after the middle of July, and the last of them were not removed until a month later. It was feared that this delay acted unfavorably on their growth, as the troughs were somewhat crowded. There were no serious losses from disease, however, as none of the epidemics occurring in past years made their appearance. The mortality in July amounted to 14,000, in August less than 5,000, and in September 2,300. To reduce the stock, 100,143 of the quinnat salmon were liberated early in September, and in October and November they were all disposed of except 5,883, which were retained throughout the winter.

The growth of the fish during the summer, though satisfactory, was not equal to that attained in former years, when maggots formed an important part of the food supply. These were not available this year, as the building erected for their production had to be transformed into a hatchery to meet the unusual demands made upon the station by the hatching of quinnat salmon the previous winter. The food material was therefore limited to the carcasses of horses and other condemned animals, beef liver, and butchers' offal.

The distribution of the fish was made by teams to local waters and by messengers to points at a distance from the station. As soon as it was completed the hatchery was filled with eggs collected from the Atlantic salmon confined in Dead Brook. The 350 female fish produced

3,506,642 eggs, which were much larger than those of the previous year, and apparently of fine quality. Notwithstanding their good condition, the actual losses from lack of impregnation and other causes, up to the time when the division was made with the State of Maine, amounted to 304,642. The United States received 2,630,214 as its share, 500,000 of which were assigned to State fish commissions and private applicants, and 2,126,975 fry, or 99.86 per cent of those divided, were hatched in March and April. Besides these, the State of Maine turned back to the Commission 540,199 fry.

Plants aggregating 1,975,000 were made in May, as follows:

Locality.	Number.
St. Croix River at Vanceboro	137, 500
Penobscot River and tributaries above Oldtown	1, 482, 500
Penobscot tributaries near Craig Brook	355, 070

The balance of the stock was retained for rearing, and at the end of June numbered 636,817.

In May, 1898, the usual arrangements were made for collecting and impounding adult salmon for the next year's brood stock; 472 fish were obtained and impounded at Dead Brook, 400 of which belonged to the United States Fish Commission.

The domesticated Atlantic salmon on hand at the beginning of the year consisted of three lots, the first of which were hatched in 1892, the second in 1893, and the third in 1897. Of the third brood 1,029 were liberated in November, 1897, reducing that lot to 454. In November 25,287 eggs were secured from the first two lots, but they were defective in quality and none of them survived to the hatching period.

As arrangements had been made to carry on landlocked-salmon work at Grand Lake Stream, no efforts were made to collect at Toddy Pond, as heretofore. In March the surplus eggs from Grand Lake Stream, amounting to 62,462, were transferred to Craig Brook, and of the fry hatched from them 54,476 remain on hand at the close of the year.

All of the rainbow trout at the station were liberated in Alamoosook Lake in August, 1897, and nothing was seen of them till the following March, when several were observed spawning in Craig Brook just below the hatchery. Measures were taken to secure eggs, and by the end of April 54,408 had been collected from 199 adult trout. The fish were undoubtedly a part of those liberated in August, and were apparently in excellent condition. The eggs were not first-class in quality, however, and only 35,000 fry were hatched. At the close of the year 28,351 remain, which appear to be doing well.

In order to test the practicability of domesticating the steelhead trout, the 191 specimens on hand from the hatch of 1896 were placed in one of the large deep ponds recently constructed and held for future service as breeders. The fish on hand from the hatching of 1897 were liberated during the fall, except 1,400, which were retained in a small pond until March, when it was found that only 180 of them remained.

This loss was first attributed to mink, but it appeared later that they were destroyed by eels. In April a consignment of 100,000 eggs was received from Fort Gaston, Cal., arriving in excellent condition. They yielded 95,904 fry, 35,941 of which were released in local waters in June. The remainder were held for rearing.

Of the Scotch sea trout resulting from eggs presented to the Commission by the journal *Shooting and Fishing* in 1891, there remains on hand a lot of 10; also two lots derived from eggs produced by these fish. All of the third lot were distributed during the year, and a crop of eggs is expected this fall from the second lot (hatched in 1895). In November, 1897, the 10 referred to above yielded 10,034 eggs, from which 2,970 young were hatched. The majority of the eggs proved defective and the fish hatched have continued to die, so that at the close of the year only 1,198 remain.

The stock on hand at the station on June 30, 1898, is as follows:

Kind.	Fish hatched in calendar year—					
	1898.	1897.	1896.	1895.	1894 or earlier.	Adult, wild-bred.
Atlantic salmon	636,264				233	400
Atlantic salmon, domesticated		454			35	
Landlocked salmon	54,476				1	
Quinnat salmon		28				
Brook trout	2,666					
Rainbow trout	28,351					
Steelhead trout	38,745		188			
Scotch sea trout	1,198			508	10	
Total	761,700	482	188	508	279	400

Grand Lake Stream.

Work was resumed at Grand Lake Stream in the fall of 1897, after a lapse of five years, arrangements having been made with the International Leather Company, of Boston, who controlled the tannery property, for the necessary land and water rights and the occupancy of the buildings. The work was directed by Mr. W. O. Buck, one of the employees of Craig Brook Station, under the supervision of the superintendent. A few needed repairs were made to the buildings in September and October, and the water supply to the hatchery was increased by the renewal of the aqueduct. Barrier nets, to prevent the salmon running downstream, were put in place about the middle of September, and pounds for their capture were set as heretofore. The fishing had been excellent the two preceding springs, and as it was now time that these waters should show the good effects of the last two years' work of the Commission (1892 and 1893), when several hundred thousand yearlings were liberated, a good season's work was expected. The catch proved small, however, the total being only 337, of which 129 were males. The longest fish captured measured 24 inches and the heaviest weighed 5 pounds. The average length and weight were 20.2 inches and 3.21 pounds for the males, and 19.7 inches and 3.36 pounds for the females. The total number of eggs taken was estimated at

1. HATCHERY AT ST. JOHNSBURY, VERMONT.

2. BOAT EQUIPPED WITH JACK LIGHTS FOR CAPTURING TROUT AT NIGHT ON THEIR SPAWNING-BEDS AT CASPIAN LAKE.

313,800, but after the unfertilized ones had been picked off there remained only 245,150. Of these, 60,000 were shipped as follows:

Consignment.	Number.	Consignment.	Number.
Connecticut Fish Commission	10,000	D. Vinciguerra, Rome, Italy	5,000
Michigan Fish Commission	10,000	Wisconsin Fish Commission	10,000
New Hampshire Fish Commission	10,000	H. W. Poor, Wilson Mills, Me	15,000

Nearly half of the remainder were transferred to Craig Brook, and the balance were held at the station to be reared and liberated in Grand Lake Stream the coming fall. At the close of the year the fish seemed to be in excellent condition. Their food consisted of beef livers, obtained once or twice a week from Calais.

ST. JOHNSBURY STATION, VERMONT (J. W. TITCOMB, SUPERINTENDENT).

On July 1 the stock of fish on hand was as follows:

Species.	Calendar year in which hatched.		
	1897.	1896.	1895.
Landlocked salmon	4,579		
Quinnat salmon	81,944		
Steelhead trout	16,379		36
Rainbow trout		437	

All of the Pacific salmon which had been held in the nursery ponds supplied by water from Sleeper River, except 1,000 retained for experimental purposes, were distributed early in July on account of the sudden rise in the temperature, which reached 82° on July 5 at 6.30 p. m., causing the loss of 14,500 of the fry. Of the fish retained, 776 were alive at the close of the fiscal year. The landlocked salmon fry were held until the end of July, when they were planted in Lakes Morey and Caspian, and the steelhead trout were planted about the same time in Lakes Morey, Willoughby, and Champlain.

During the summer preparations were made for securing a supply of brook-trout eggs from wild trout by the establishment of auxiliary field stations. The stations operated the previous year at Darling Pond, Groton, and at Caspian Lake, Greensboro, were put in order, and the superintendent visited Willoughby Lake at Westmore, Ewel's Pond at Peacham, Garfield Pond at Danby, Silsby's Pond at Newbury, and a number of others, with a view to operating experimental stations at those points. As a result of his investigations, operations were undertaken at Lakes Willoughby and Ansil, and at the ponds of the Wells River Fish and Game Club. The only results secured from these were 14,525 lake-trout eggs at Willoughby Lake; and as the expense involved in the collection of these was great, the work was abandoned.

Work at Caspian Lake was begun on October 11, and continued until the 27th, when operations were discontinued, as only 66,022 brook and lake trout eggs had been secured. The failure at this point was appar-

ently either because the fish did not ascend to the usual spawning-grounds, or spawned in the deeper water under the ice. It is believed that a large number of lake-trout eggs may be collected at this point in the future by the use of fyke nets. This station is well equipped for eyeing 800,000 trout eggs, and is regarded as one of the best fields in the State for collecting brook and lake-trout eggs.

At Darling Pond, Groton, the trap was put in on July 20, and kept in place until November 6. The temporary hatchery was opened on September 1 and closed on December 31, during which time 682,248 trout eggs were collected, 83 per cent of which were transferred to St. Johnsbury when they had reached the eyed stage. The results at this station were very satisfactory, for although in the previous season 961,318 eggs were collected, only 23 per cent were saved—the loss being apparently due to the improper handling of the eggs. During the season, 5,000 trout were handled; of these, 1,734 were ripe females. The temporary hatchery is an abandoned farmhouse, supplied with about 45 gallons of spring water per minute, and can be operated economically. The experience at Darling Pond would indicate that the eggs taken from fresh-run fish are much stronger and yield a better percentage of fry than those taken from fish that have been confined for several weeks before they are ripe, as is necessary here.

At Fairbanks Pond 78,547 eggs were collected by the employees of the station, of which 70 per cent were hatched. Of the total number collected 120,300 were shipped to applicants in Eastern States and in Europe. The balance and an additional 200,000 purchased were held at the station to be hatched and distributed during the spring.

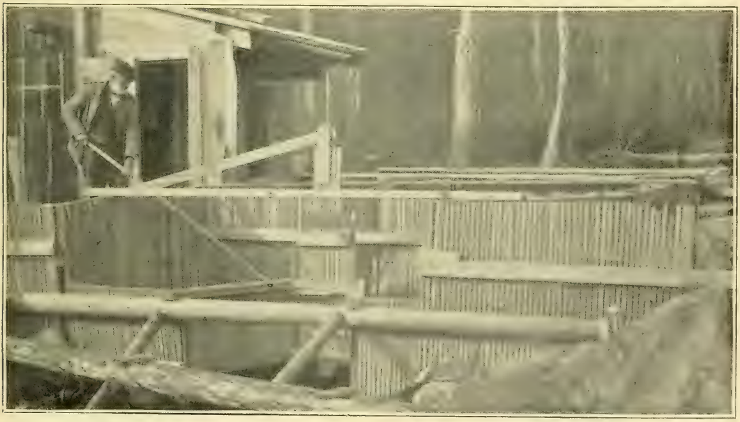
The brook-trout eggs hatched during February and March, with comparatively small loss, over 716,000 fry being produced; 561,000 of these were planted in April, May, and June. The lake-trout eggs produced 14,000 fry, which in the spring were planted in Lake Dunmore and in ponds at Derby.

At the request of H. F. Hurlbut, of East Freetown, Mass., and of Charles A. Hoxsie, of Carolina, R. I., 70,000 eggs collected from wild trout were exchanged for the same number produced at their hatcheries.

On February 23, 10,000 landlocked-salmon eggs were received from Green Lake Station, only 50 dead ones being picked out on their arrival. Of this shipment 9,900 hatched, and at the close of the year 9,138 fry were on hand, which are held for distribution in Vermont waters. Of 100,000 steelhead-trout eggs received from Fort Gaston on March 23, 91,000 fry were planted during May and June.

At the close of the year the stock on hand was as follows:

Species.	Calendar year in which hatched.			
	1898.	1897.	1896.	1895.
Steelhead trout	3,963	....	....	35
Rainbow trout	....	....	410	....
Pacific salmon	....	776	....	....
Brook trout	6,199	....	....	....
Landlocked salmon	9,138	....	....	....



TWO VIEWS OF TRAP AT GROTON, VERMONT, 1897.

The Pacific salmon fry placed in the ponds for experimental purposes weighed 1 pound 10 ounces to the thousand on July 1. These were confined in a pond about 8,000 square feet in area. In January, 1898, they weighed 41 to the pound, and in June the average weight had increased to 12 to the pound. Great dissimilarity was noticed in the color and shape of lake-trout eggs taken from different waters. For example, the eggs of the lake trout taken at Willoughby Lake closely resemble those of the landlocked salmon, and are much larger than those from Caspian Lake, 600 of the Willoughby Lake eggs equaling 4 fluid ounces, while it required 800 from Caspian Lake to fill the same measure. It was also noticed that the fry hatched from the Caspian Lake eggs were much smaller and more active.

During April, as the troughs in the hatchery were much crowded, some of the fry were transferred from them to the nursery ponds, 10,000 to each pond. These ponds had not been used for six months, and were supplied with water from Sleeper River. The fry in the ponds had the same care as in the hatchery, except that it was impossible to clean them as thoroughly. No unusual mortality was observed, and at a careful examination of the outlets, to see if the fry were escaping, everything appeared to be perfectly tight; but on June 6, when these fish were taken from the ponds for shipment, only 25 per cent of the number originally placed there were found. It is difficult to account for the disappearance of the balance, though it was possibly due to cannibalism, as the fish taken from the ponds were at least three times as large as those of the same age taken from the troughs. This larger growth may to some extent be due, however, to higher temperature of the water, and to the presence of some natural food. It was observed that under the same conditions—i. e., with the same number of brook trout, steelhead trout, and landlocked salmon, in ponds of equal size—the landlocked salmon stand a much higher temperature than any of the others.

The food used at the station has consisted principally of livers, with the addition of insect larvæ obtained from the refuse of livers, crows, woodchucks, etc. One woodchuck produced 1 quart of maggots.

Enemies of the fish have been the source of but little trouble during the past year, except in the case of the kingfisher, many of which have been killed. In October a colony of muskrats made their headquarters in one of the ponds, and before they had been discovered had made 12 holes in the banks, one of which caused a leak. These animals were shot and trapped. All were males, indicating that the males precede the females in the preparation of the winter homes. Mink were seen occasionally along the river, but no trouble was experienced from them.

Several landlocked salmon from the plants made by the Commission were caught with hook and line at Lake Morey, Fairlee, Vt., in May, 1897, and it is expected that in a few years this lake will afford a valuable field for the collection of this species. In May, 1898, a landlocked salmon weighing 4¾ pounds was taken at Caspian Lake. In Sleeper River, which is the source of the water supply for the St. Johnsbury Station, rainbow and brook trout, quinnat salmon, Atlantic salmon,

and steelhead trout have been taken during the year. The plants were made in the headwaters of the river, but the fish worked down to the lower and deeper pools. The steelheads and Pacific salmon captured in Sleeper River averaged about 6 inches in length, while the rainbow trout ran from 6 to 12 inches; Atlantic salmon ranged from 5 to 7 inches. All of these fish were taken with angleworms, though the Pacific salmon will rise quite readily to the fly. The capture of steelhead trout and landlocked salmon is also reported from tributaries of Lake Champlain, but in some instances the varieties have not been thoroughly identified.

During the year the north embankment of the reservoir was rebuilt, and a tiled drain (144 feet in length) was laid below its base. The reservoir roof was covered with a preparation of tar and gravel, and the filter in the reservoir was renewed. The interior of the reservoir, containing about a foot of mud, was cleaned out, the sides washed down, and the entire interior given a whitewash coat of cement. A pipe was connected with the supply standpipe in the reservoir filter, and run through the filter crib into the reservoir, giving the latter a direct supply of water from the river in case of emergency. A ventilator was placed in the reservoir roof to ventilate the reservoir and prevent heating under the roof, and the consequent decay of timbers. Seven new ponds were constructed—Pond H and six small rearing-ponds. The spring-water supply to the hatchery was connected directly with the distributing crib, for use in the ponds when the hatching-troughs were not in use. The arrangement of the hatching and picking troughs was changed so as to place the latter under the windows on the east side of the hatchery, and supply all the troughs with the water from the west side, instead of from both sides, as formerly. This change gives more floor space, connects all troughs with the spring-water supply, and reduces the amount of water required in the hatchery. Its successful operation during the season indicates a great improvement.

On September 27 ground was broken for the construction of a residence for the superintendent. The work was continued throughout the winter and the house completed on June 30, except the interior finishing. The residence consists of ten rooms and is a two-story frame house, with stone and brick foundation, heated by furnace and supplied with modern plumbing.

Under authority of act of Congress, authorizing an expenditure of $3,000 for an increased supply of water at the station, a contract was entered into with Carpenter & Williams on April 20, 1897, for an artesian well. Work was commenced on April 21, and at the close of the fiscal year a well 200 feet deep had been sunk.

CAPE VINCENT STATION, NEW YORK (LIVINGSTON STONE, SUPERINTENDENT).

The hatching apparatus was thoroughly overhauled during the summer and the first floor of the hatchery fitted up with Williamson troughs, preparatory to hatching quinnat-salmon eggs, which were to be transferred from the Pacific coast. The old method of securing water by means of pumps was abandoned this year and arrangements

were made for obtaining the amount needed from the city waterworks company; this change has not only reduced expenses, but the quality of the water is better and the supply more reliable.

During October 133,140 lake-trout eggs were purchased from the fishermen operating on Charity Shoals at a rate of 15 cents per 1,000, and the 114,481 fry resulting from them were planted in Watson Bay. An assignment of 1,000,000 eggs of this species was also received from Northville, and the fry hatched, amounting to 967,850, were deposited in Lake Ontario and the St. Lawrence River.

In December 5,000,000 eggs of the quinnat salmon were received from Battle Creek, Cal. The fry hatched were carried through the winter without material loss, and with the exception of one plant of 328,000 in the Salmon River, they were all distributed in Lake Ontario and the St. Lawrence River within a radius of 25 miles from the station.

Consignments of 100,000 each of brook trout, steelhead trout, and Atlantic salmon eggs were received during the year from other stations, and were hatched and distributed as usual; 10,000 steelhead eggs were repacked and shipped to Osnabruck, Germany, where they arrived with the loss of only 420, after a journey of nearly 8,000 miles.

Early in the spring the superintendent made an investigation of various fishing-grounds on Lake Ontario to arrange for the collection of pike-perch eggs, as there was a general desire on the part of the fishermen on the lake that the propagation of this species be undertaken. The investigation showed that there are no localities in the vicinity where eggs can be obtained in large quantities, though the spawning fish formerly occurred in great abundance throughout this region. The fishermen stated that where tons of fish had been captured two years ago, there was now practically no fishing. The disappearance of fish from their usual spawning-grounds was attributed by some persons to the discharge of refuse from mills and factories into the tributaries of Lake Ontario. In April 30,000,000 eggs of the pike perch were transferred from Put-in Bay, and the majority of the fry resulting from them were planted without loss in the St. Lawrence River; one plant of 800,000 being made in the Oswegatchee River. It is reported that pike perch are abundant in some of the inland lakes of the State, and a collecting station, similar to the one operated by the New York Fish Commission on Lake Oneida at Constantia, may be established in the future.

The following shows the number of eggs handled and fry hatched at the station during the fiscal year:

Species.	No. of eggs received.	Fry hatched.
Lake trout	1,133,140	982,331
Quinnat salmon	5,000,000	4,690,801
Brook trout	100,000	56,000
Atlantic salmon	100,000	97,071
Steelhead trout	100,000	90,060
Pike perch	30,000,000	10,043,750
Total	36,433,140	15,960,013

An investigation was made by the superintendent with the view to undertaking the propagation of sturgeon, but no point could be found at which a sufficiently large number of spawning sturgeon are caught to warrant the establishment of a field station, although sturgeon nets are fished all the way from Ogdensburg to the eastern end of Lake Ontario.

GLOUCESTER STATION, MASSACHUSETTS (C. G. CORLISS, SUPERINTENDENT).

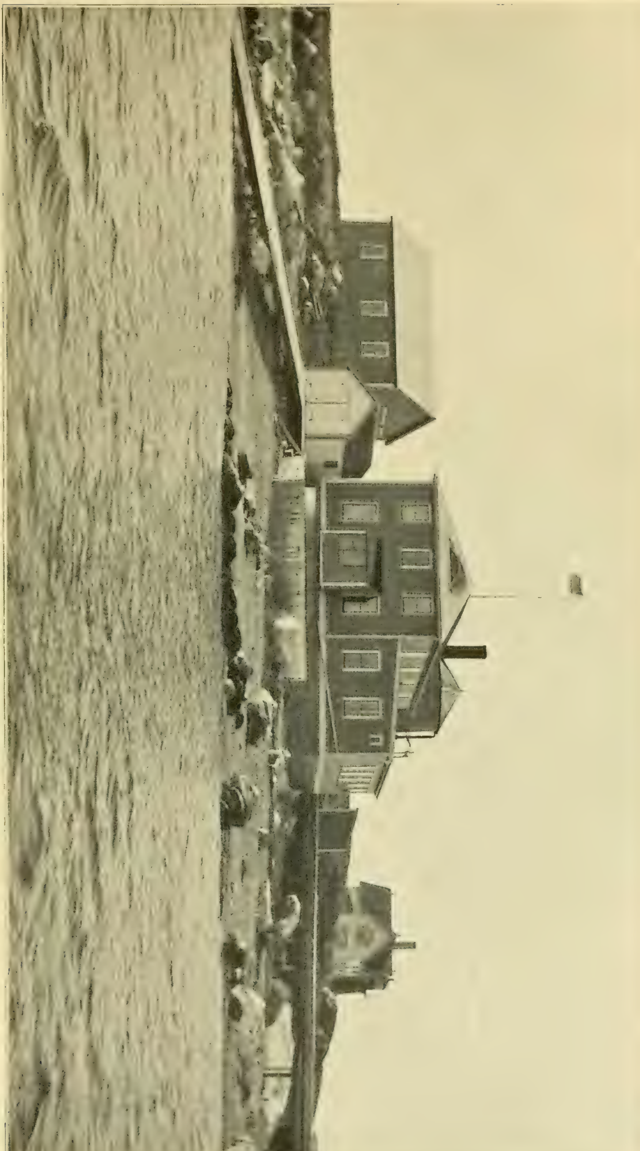
As soon as practicable after the 1st of July preparations were made for increasing the size of the hatchery and of the pumping plant. A one-story addition, 18 by 32 feet, was built on the northwest side of the hatchery and equipped with 6 new tables, containing 72 hatching-boxes, thereby doubling the capacity of the hatchery for cod work. A 40-horsepower boiler was installed in place of the small one which had been used for a number of years.

Immediately upon the completion of this work a force of spawn-takers was employed, and efforts were made to collect pollock eggs from the fisherman at Gloucester. As a result 7,791,000 eggs were collected during November and December, which produced 4,455,000 fry. The failure to secure the much larger results, which had been anticipated, was due to the method of fishing, all of the pollock being captured with hand lines instead of with gill nets, which had been formerly used. It is claimed that ripe spawning fish seldom take the hook.

On November 15 the crew of the *Grampus*, under the direction of Capt. E. E. Hahn, was stationed at Kittery Point for the purpose of collecting cod eggs. The methods pursued were practically the same as in past years. The eggs were collected by spawn-takers from fish captured by vessels having headquarters near Kittery. Arrangements were also made for purchasing eggs at $5 per 1,000,000 from fishermen not accompanied by spawn-takers. On the first of March collections were discontinued at Kittery, as the *Grampus* force was needed for the work on the vessel, and the last of the fry were hatched on March 26. A few eggs were purchased after that date. The total collection of the season amounted to 160,711,000, the first being secured on November 17. The 96,707,000 fry produced were distributed along the Massachusetts coast from Ipswich Bay to Massachusetts Bay, off Baker Island, from 1 to 10 miles from the shore, on the natural spawning-grounds.

Record of cod-hatching at Gloucester Station, season of 1897–98.

When received.	Source of supply.	Eggs received.	Loss during incubation.	Fry hatched.	Date of hatching.	Date of planting.
1897.					1897.	1897.
Nov. 17	Kittery Point	2,480,000	761,000	1,719,000	Nov. 29	Nov. 30
18	.....do	1,272,000	516,000	756,000	30	30
19	.....do	2,238,000	478,000	1,760,000	Dec. 1	Dec. 1
20	.....do	515,000	176,000	339,000	3	3
22	.....do	2,921,000	599,000	2,322,000	5	5
23	.....do	2,785,000	692,000	2,093,000	6	7
24	.....do	1,470,000	416,000	1,054,000	7	7
25	.....do	482,000	71,000	411,000	9	9
28	.....do	1,416,000	525,000	891,000	13	13
29	.....do	3,440,000	671,000	2,769,000	13	13
Dec. 1	.....do	3,950,000	1,084,000	2,866,000	15	15
2	.....do	166,000	18,000	148,000	16	16



HATCHERY AT GLOUCESTER, VIEW FROM GLOUCESTER HARBOR

Record of cod-hatching at Gloucester Station, season of 1897–98—Continued.

When received.	Source of supply.	Eggs received.	Loss during incubation.	Fry hatched.	Date of hatching.	Date of planting.
1897.					1897.	1897.
Dec. 3	Kittery Point	2,896,000	958,000	1,938,000	Dec. 17	Dec. 17
4	do	1,021,000	473,000	548,000	17	17
5	do	1,398,000	562,000	836,000	17	17
6	do	2,751,000	681,000	2,070,000	20	20
10	Kittery Point and Gloucester	2,264,000	775,000	1,489,000	26	26
11	do	2,460,000	1,285,000	1,175,000	26	26
12	do	1,924,000	610,000	1,314,000	27	27
13	do	6,074,000	2,871,000	3,203,000	28	28
					1898.	1898.
14	do	2,114,000	1,527,000	3,752,000	Jan. 2	Jan. 2
16	do	11,894,000	7,594,000	4,275,000	4	4
17	do	7,896,000	3,667,000	4,302,000	7	7
18	do	1,205,000	697,000	508,000	4	4
20	do	7,484,000	4,137,000	134,000	10	10
21	do	1,069,000	781,000	288,000	10	10
22	Gloucester and Plymouth	2,817,000	1,951,000	866,000	10	10
23	Gloucester	164,000	32,000	132,000	10	10
26	do	677,000	118,000	559,000	10	10
27	Kittery Point	3,176,000	925,000	2,251,000	12	12
28	do	1,306,000	316,000	990,000	12	12
29	do	1,503,000	623,000	880,000	14	14
30	do	316,000	86,000	230,000	14	14
31	do	2,601,000	1,093,000	1,508,000	17	17
1898.						
Jan. 2	do	4,239,000	1,909,000	2,330,000	19	19
4	Kittery Point and Plymouth	5,124,000	2,156,000	2,968,000	19	19
5	Kittery Point	1,372,000	694,000	678,000	21	21
6	do	768,000	257,000	511,000	21	21
8	do	1,492,000	820,000	672,000	25	25
9	do	871,000	363,000	508,000	25	25
10	Kittery Point and Rockport	1,883,000	899,000	984,000	25	25
11	Kittery Point	571,000	217,000	354,000	25	25
12	Rockport	1,717,000	1,064,000	653,000	27	27
13	Rockport and Kittery Point	2,370,000	504,000	1,866,000	27	27
14	Kittery Point	864,000	283,000	581,000	29	29
15	Rockport and Kittery Point	5,317,000	1,883,000	3,434,000	29	29
16	do	3,881,000	1,367,000	2,514,000	Feb. 3	Feb. 3
17	do	2,168,000	1,535,000	633,000	3	3
18	do	7,474,000	2,182,000	5,292,000	4	4
19	do	4,235,000	2,344,000	1,891,000	3	3
20	Kittery Point	74,000	31,000	43,000	7	7
21	Rockport and Kittery Point	1,468,000	652,000	816,000	7	7
22	Kittery Point	1,934,000	987,000	947,000	7	7
25	do	1,489,000	402,000	1,087,000	11	11
27	Rockport and Kittery Point	3,868,000	986,000	2,882,000	13	14
28	do	1,504,000	347,000	1,157,000	14	14
30	Kittery Point	1,920,000	1,062,000	858,000	18	18
Feb. 3	do	166,000	74,000	92,000	20	23
5	do	308,000	42,000	266,000	21	23
6	Rockport	400,000	86,000	314,000	22	23
7	Kittery Point	1,085,000	209,000	876,000	23	23
8	Kittery Point and Plymouth	2,030,000	472,000	1,558,000	23	23
9	Kittery Point	895,000	299,000	596,000	26	26
10	Rockport	1,862,000	589,000	1,273,000	26	26
11	Kittery Point	616,000	170,000	446,000	26	26
13	Kittery Point and Gloucester	1,472,000	253,000	1,219,000	28	28
14	Kittery Point	1,128,000	132,000	996,000	28	28
19	do	532,000	91,000	441,000	Mar. 7	Mar. 7
26	do	327,000	63,000	264,000	16	17
28	Gloucester	1,364,000	190,000	1,174,000	17	17
Mar. 6	Rockport	760,000	116,000	644,000	21	21
10	do	1,600,000	221,000	1,379,000	24	24
14	do	1,418,000	284,000	1,134,000	26	26
	Total	160,711,000	64,004,000	96,707,000		

The eggs transferred from Kittery to Gloucester were packed in tightly sealed jars and surrounded with crushed ice or snow, in charge of a messenger. As a rule they were of excellent quality, and were hatched as heretofore in the McDonald cod-box. As the water temperature fell it became necessary to use steam to maintain a temperature of between 38° and 40°, which has been found by experiment to be about the same as the temperature of the water on the natural spawning-grounds.

At the close of the cod season arrangements were made with the fishermen and dealers to save egg-lobsters at various points along the Massachusetts coast, and temporary collectors were employed and stationed at Boston and Kittery Point to look after the interests of the Commission in this work. The schooner *Grampus* was detailed to make collections along the Maine coast from Kittery to Rockland, and on account of the large extent of territory to be covered an additional steam smack was chartered to work in connection with the *Grampus*. As a result of operations on the coast of Maine, 22,023,000 lobster eggs were collected and delivered at the station. The first eggs were taken by the *Grampus* on April 11, and the collections were continued daily from that time until July 15. The lobsters purchased in Gloucester and vicinity, Kittery Point, Marblehead, and Boston were transferred to the station by means of a steam launch. This launch was also utilized in making the plants.

The collections made at the various points aggregated 6,445 lobsters, which yielded 72,101,000 eggs. The eggs were all hatched at Gloucester, and produced 65,097,000 fry, which were distributed along the New England coast from Rockland to Boston. Several of the shipments were taken to Maine waters by the *Grampus*, and a number of shipments were sent by rail in care of messengers to Portland, Maine, from which point they were distributed by the schooner. Heretofore considerable difficulty had been experienced in shipping lobster fry during warm weather on account of losses occasioned by sudden rises in temperature, as ice could not be used in the transportation cans, because it would reduce the density of the water. This year, by a simple device, the difficulty was overcome. A tin cylinder, attached to the cover of the regular transportation can and extending to within 6 inches of the bottom of the can, was kept constantly filled with crushed ice, and in this way the proper temperature of the water was maintained.

The following table shows the number of eggs collected from the various fields:

Locality.	Eggs collected.
Gloucester and vicinity	6,479,000
Marblehead	435,000
Kittery Point and vicinity	6,368,000
Maine coast, schooner *Grampus*	22,023,000
Boston and vicinity	36,796,000
Total	72,101,000

WOODS HOLE STATION, MASSACHUSETTS (E. F. LOCKE, SUPERINTENDENT).

During July and August various repairs were made to the residence and other buildings, including a new floor for the lower hall of the laboratory and repairs to the pool. The machine shop was removed from the loft over the fire-room to the lower floor of the carpenter shop.

The station force collected in July for shipment to the Pacific coast a carload of 2,017 small and 12 adult tautog, with 119 blue crabs.

INTERIOR VIEW OF GLOUCESTER HATCHERY, SHOWING COD BOXES IN OPERATION.

The bulk of these being lost en route, a second collection was made in November for shipment to the same point, which comprised 1,138 tautog and 150 lobsters. The force was also utilized during the spring in collecting a carload of live fishes, including forty-five species, for the Omaha Exposition, and two carloads of salt water were filtered and shipped to Omaha on May 1.

Arrangements were made for gathering information in regard to the movements, growth, spawning habits, etc., of the cod by attaching small tags to brood fish liberated at the close of the season.

The collection of brood codfish was made as usual by the schooner *Grampus* and by purchase from fishing-smacks. The first fish were received on October 8 and the last on November 9; in all 3,507 were secured. The minimum weight of the fish accepted was 6 pounds; 1,920 of them were caught by the *Grampus* and the remainder obtained from the fishermen. They were carefully transferred from the vessel to live-cars moored in the pool. The loss during October was normal, but about the middle of November the mortality became very heavy, and specimens of the dead fish were sent to Washington for examination. It was found that in a majority of cases the primary cause of death could be traced to hook wounds or other injuries received at the time of capture.

From the penned brood-fish 57,034,000 eggs were secured.

Arrangements were made for collecting cod eggs at Plymouth, Mass., by Capt. E. E. Hahn. A force of spawn-takers was stationed there in November under direction of F. S. Conley, the first officer of the *Grampus*, and the launch *Cygnet*, with a crew, was assigned for use in transferring the spawn-takers from the shore to the fishing vessels. About December 1 the force was increased to seven spawn-takers, the collection of eggs was commenced, and although the work was frequently interrupted by storms during winter, the season as a whole was favorable, resulting in the collection of 90,760,000 eggs.

The method of handling and packing eggs did not differ from that followed at Kittery. The eggs were usually sent by express, though in the case of large collections a messenger was sent with them to guard against accident. The majority of the eggs arrived at the station in excellent condition. The work was continued until February 26, at which time, as a result of the collections made at this point and from the fish penned at the station, 147,794,000 eggs had been collected. Several shipments were also received from Kittery Point, amounting in all to 5,642,000. These were sent by messenger as far as Boston, and then shipped in care of the baggage-master to Woods Hole. The total number of eggs handled at the station amounted to 153,436,000.

The eggs were hatched, as usual, in the McDonald cod box, steam being utilized to maintain an equable temperature of water when that in the hatchery fell below 40°. The fry were planted on the spawning-grounds off Gayhead, with the exception of 6,340,000, which were deposited near Provincetown, Mass.

Record of cod-hatching at Woods Hole Station, 1897–98.

Date.	Source of supply.	Eggs taken.	Loss during incubation.	Fry hatched.	Date of hatching.	Date of planting.
Nov. 15	Live-cars	474, 000	147, 000	269, 000	Nov. 27	Nov. 30
16	....do	805, 000	108, 000	550, 000	28	30
17	....do	237, 000	26, 000	148, 000	28	30
20	....do	947, 000	131, 000	679, 000	Dec. 1	Dec. 3
22	....do	380, 000	42, 000	275, 000	2	3
26	....do	2, 227, 000	442, 000	1, 280, 000	8	9
30	....do	3, 649, 000	693, 000	2, 218, 000	13	14
Dec. 1	Plymouth	948, 000	185, 000	626, 000	14	15
2	Live-cars	3, 222, 000	506, 000	2, 305, 000	14	15
2	Plymouth	853, 000	79, 000	737, 000	14	15
4	Live-cars	3, 511, 000	599, 000	2, 462, 000	16	17
4	Plymouth	853, 000	100, 000	653, 000	16	17
6	....do	587, 000	215, 000	335, 000	19	20
6	Live-cars	2, 075, 000	548, 000	1, 290, 000	19	20
7	Plymouth	474, 000	121, 000	332, 000	19	20
7	Live-cars	758, 000	189, 000	485, 000	19	20
8	....do	3, 221, 000	900, 000	2, 084, 000	20	21
8	Plymouth	806, 000	400, 000	322, 000	20	21
11	....do	1, 232, 000	329, 000	876. 000	23	27
11	Live-cars	4, 122, 000	1, 003, 000	2, 690, 000	23	27
13	....do	5, 331, 000	933, 000	3, 866, 000	27	29
14	Plymouth	2, 535, 000	633, 000	1, 555, 000	27	29
15	Live-cars	3, 815, 000	853, 000	2, 445, 000	31	Jan. 3
16	Plymouth	568, 000	100, 000	394, 000	31	3
16	Live-cars	1, 422, 000	404, 000	724, 000	Jan. 3	6
16	Plymouth	853, 000	111, 000	605, 000	3	6
17	....do	1, 611, 000	429, 000	1, 045, 000	5	6
18	Live-cars	4, 667, 000	1, 004, 000	3, 079, 000	7	8
20	Plymouth	2, 180, 000	437, 000	1, 396, 000	9	10
21	Live-cars	2, 417, 000	594, 000	1, 564, 000	9	10
20	Plymouth	568, 000	152, 000	374, 000	9	10
21	....do	3, 008, 000	157, 000	2, 674, 000	9	10
22	Kittery Point	1, 611, 000	515, 000	969, 000	12	15
22	Plymouth	1, 256, 000	210, 000	945, 000	12	15
23	Live-cars	2,123, 000	447, 000	1, 497, 000	13	15
23	Plymouth	1, 090, 000	79, 000	970, 000	13	15
23	Kittery Point	1, 422, 000	232, 000	1, 048, 000	13	15
26	....do	2, 559, 000	798, 000	1, 623, 000	16	18
28	Live-cars	2, 440, 000	702, 000	1, 537, 000	18	22
29	Plymouth	2, 985, 000	519, 000	2, 249, 000	18	22
30	Live-cars	1, 374, 000	374, 000	773, 000	22	25
30	Plymouth	1, 231, 000	126, 000	989, 000	22	25
31	....do	616, 000	252, 000	322, 000	22	25
Jan. 2	....do	4, 264, 000	1, 037, 000	3, 055, 000	22	25
3	Live-cars	616, 000	155, 000	398, 000	24	25
5	....do	663, 000	136, 000	485, 000	27	31
6	Plymouth	1, 137, 000	236, 000	816, 000	27	31
7	Live-cars	996, 000	242, 000	658, 000	27	31
8	Plymouth	711, 000	90, 000	593, 000	27	31
9	....do	2, 130, 000	253, 000	1, 767, 000	31	Feb. 3
10	Live-cars	1, 137, 000	242, 000	784, 000	31	3
10	Plymouth	995, 000	41, 000	886, 000	31	3
11	....do	2, 464, 000	1, 048, 000	1, 3[illegible], 000	Feb. 4	7
12	Live-cars	900, 000	253, 000	573, 000	4	7
12	Plymouth	592, 000	105, 000	419, 000	4	7
14	Live-cars	663, 000	169, 000	447, 000	7	8
15	Plymouth	2, 037, 000	221, 000	1, 722, 000	7	8
16	....do	1, 943. 000	189, 000	1, 613, 000	7	8
17	Live-cars	758, 000	205, 000	511, 000	12	14
18	Plymouth	2, 178, 000	632, 000	1, 314, 000	12	14
19	....do	7, 250, 000	1, 893, 000	4, 989, 000	12	14
19	Live-cars	711, 000	200, 000	511, 000	12	14
20	Plymouth	1, 659, 000	99, 000	1, 519, 000	15	18
21	Live-cars	332, 000	42, 000	280, 000	15	18
21	Plymouth	1, 659, 000	105, 000	1, 492, 000	15	18
22	....do	758, 000	42, 000	701, 000	15	18
24	Live-cars	711, 000	237, 000	442, 000	19	22
25	Plymouth	5, 543, 000	1, 032, 000	4, 087, 000	19	22
27	Live-cars	190, 000	105, 000	69, 000	19	22
Feb. 1	....do	190, 000	147, 000	33, 000	25	25
6	Plymouth	4, 265, 000	1, 424, 000	2, 558, 000	28	Mar. 2
7	....do	1, 564, 000	197, 000	1, 332, 000	Mar. 2	4
8	....do	616, 000	97, 000	435, 000	2	4
9	....do	1, 943, 000	432, 000	1, 470, 000	2	4
11	....do	1, 516, 000	547, 000	929, 000	6	8
12	....do	758, 000	131, 000	585, 000	6	8
13	....do	1, 611, 000	195, 000	1, 320, 000	6	8
14	....do	2, 284, 000	538, 000	1, 674, 000	9	11
15	....do	2, 559, 000	934, 000	1, 471, 000	9	11
18	....do	6, 304, 000	1, 073, 000	4, 793, 000	14	15
19	....do	5, 634, 000	2, 171. 000	3, 099, 000	16	17
23	....do	426, 000	16, 000	389, 000	18	19
26	....do	1, 706, 000	570, 000	1, 074, 000	18	21
	Total	153, 436, 000	34, 305, 000	105, 863, 000		

The results secured with cod this year were far better than heretofore, and it is believed the work can be still further extended and increased by enlarging the force at Plymouth and using a larger steamer for transferring the spawn-takers to and from the fishing vessels.

Early in February steps were taken to collect the winter flounder or flatfish. For this purpose several fyke nets were set in Woods Hole harbor and Waquoit Bay, and the brood-fish taken were held at the station until ripe, when they were stripped and liberated. The first ripe fish were taken on February 11 in Woods Hole harbor, but owing to the presence of ice in Waquoit Bay the nets could not be set there until the 18th. The appearance of spent fish in the nets immediately after they had been set at the latter point indicated that the fish had commenced spawning much earlier, and that in order to do good work there it will be necessary to commence operations in January, weather permitting. Most of the fish taken were quite small, and the yield per fish was lighter than in past years. In 1897, 205 females produced 84,591,000 eggs, while this year 249 females yielded only 52,799,000, the average yield in 1897 being 456,000 per fish, and this year only 226,000. During the latter part of March efforts were made to secure eggs at East Greenwich, R. I. While only 4,804,000 were obtained here, it is thought that large numbers can be taken another season by stationing a man there to collect and forward the eggs early in February. Work closed on April 8, with a total take of 57,603,000, which produced 39,337,000 fry.

Following the custom of previous years, arrangements were made with local fishermen to take care of all egg-lobsters collected during the fall and winter, and between December 7 and January 19 about 500,000 eggs were secured. These were placed in jars, and developed fairly well until April 1. After that time the loss became very heavy and only about one-third of them hatched. Active operations commenced about April 1 and continued until June 30. The territory covered embraced all points fished within a radius of 15 miles from the station, and a schooner was employed to collect egg-lobsters at New London, Noank, and Stonington, Conn., and Block Island, R. I., while an agent was stationed at Plymouth, Mass., to collect from the fishermen located between Green River and Ship Pond, a distance of about 20 miles. Later in the season arrangements were made to collect eggs at Scituate, Mass., but only a few were received from that point. It is believed, however, that this section will yield a much larger number next year. Although the work was pushed energetically throughout the season, none of the territory covered yielded as many eggs as heretofore.

The following table shows the number received from the different localities in 1897 and 1898:

Localities.	1897.	1898.
Noank, Stonington, and Block Island	33,804,000	19,343,000
Woods Hole and vicinity, including Vineyard Sound and Buzzards Bay	35,013,000	11,620,000
Plymouth	5,335,000	4,428,000

The greatest difference will be noted as occurring in the vicinity of the station. This is attributed, first, to the well-known fact that the lobster fishery is steadily declining in this section; hence, the number of men engaged in the work becomes fewer each year, as the income derived from it is too small to support them. Another important factor is the legislation recently enacted prohibiting the fishing of pound nets in Buzzards Bay, which furnished the greater part of the bait used by the lobster fishermen operating in this territory. This caused a number of men to abandon the business. The same general decline has been felt in the waters south and west. It is reported that only about half the number of pots were set in the vicinity of Marblehead, Stonington, and Block Island, as compared with the previous year. The only direction in which operations could be extended would be on the north side of Cape Cod; but an additional steam launch would be necessary, which would materially increase the expense of the work.

The following table shows the species handled at the station during the fiscal year, eggs collected, and fry produced.

Species.	No. of eggs.	No. of fry.
Cod	153,436,000	105,863,000
Flatfish	57,603,000	39,337,000
Lobster	35,391,000	30,980,000
Total	246,430,000	176,180,000

EDISTO RIVER, STEAMER FISH HAWK (LIEUT. FRANKLIN SWIFT COMMANDING).

As a result of investigations made by the assistant in charge during December, the *Fish Hawk* was detailed to visit the Edisto River in March for the purpose of determining whether the fisheries are of such character and extent as to permit of fish-cultural work on a large scale. The vessel arrived at the mouth of the river on March 12 and proceeded upstream to a point a mile above the mouth of the Dawho, where good anchorage was obtained. That night 8 spawn-takers were sent out to examine the shad captured by the fishermen, and as a result 77,000 eggs were collected. These were placed in the jars and seemed to be in good condition until the 17th, when they commenced dying rapidly. As the temperature was favorable, averaging 66°, and the embryo was well formed, it was thought that the water was at fault, and it was tested for acids, but none were found. It is barely possible that the loss was due to the use of salt water in the pipes and machinery at Tampa; but this is not probable, as the pipes had been thoroughly rinsed with fresh water before the eggs were placed in the jars, and only a very slight trace of salt could be found when chemicals were used to test the water. The spawn-takers continued attending the nets, but no more eggs were obtained, though the fishermen reported that ripe fish had been caught for a week or ten days prior to the arrival of the vessel. The majority of those caught were hard and would have required at least a week to ripen, and, as the services of the vessel were needed on the Albemarle, work was discontinued on the 18th.

The present method of fishing on this river is such that fish-cultural work on a large scale is not practicable. Only one small seine is used; the balance of the fishermen use set gill nets, which are put out at low water and not overhauled till high-water slack. They remain in water until morning, when they are taken up and the fish removed, hence the only opportunity for spawn-takers to obtain the fish alive would be when they are first overhauled. The haul seine referred to is worked by 5 men and is fished only at low water during the day. Drift nets can not be used in this river on account of snags, shoals, and other natural obstacles. Gill-net fishing extends from a mile above the Savannah and Charleston Railroad crossing at Jacksonboro down to the Dawho River. This part of the river is known locally as the Pon Pon. There are 37 crews of 2 men each fishing in this region, each crew using two nets. They obtain an average of 1,000 fish per crew, though in the vicinity of the Oakhurst plantation, where the old State fish-hatchery is located, the catch is much larger, some crews taking from 1,800 to 3,000 per season. The State operated the hatchery referred to from 1880 to 1884, inclusive, and collected annually from 3,000,000 to 5,000,000 eggs. This hatchery is about centrally located as regards the fishing area, the contour of the river in that vicinity showing it to be especially adapted for spawning-grounds. If drift nets and haul seines were used, there would be little difficulty in collecting from 15,000,000 to 20,000,000 eggs each season.

During the stay of the vessel on the river the officers in command were indebted to S. Fitzsimons, Morton Simons, and T. D. Ravenel for assistance and courtesies extended.

Albemarle Sound, Steamer Fish Hawk.

Owing to a delay of some days at Ocracoke Inlet on account of the extremely low tide, the vessel did not reach Avoca until March 28. Anchorage was made at the entrance to Salmon Creek on account of its proximity to the fishing-grounds and because of the partial shelter which it affords to the ship's boats. Spawn-takers were immediately sent to the fishing-grounds controlled by Dr. W. R. Capehart and Mr. T. D. Holly, and 147,000 eggs were secured from these sources on the first day. It was also intended to collect from the seines on the Roanoke and from those controlled by the Wood Brothers across the bay, but as very few fish were being taken at these points the attempt was abandoned. Eggs continued to come in daily from the arrival of the vessel until April 25, the total take aggregating 12,334,000. Of these, 10,242,000 were secured from Dr. Capehart's seines.

The results attained in this region would undoubtedly have been much better had the weather conditions been more favorable. It was exceedingly warm during March, and consequently the number of fish captured then was unusually large, the take at one fishery being four times as great as that of the preceding year for the same period. About the time the vessel arrived it became much cooler, and the mean temperature from March 30 to April 19 was under 60°. This tended not only to

keep the spawning fish out in deep water, but it greatly retarded the hatching of the eggs and caused the death of large numbers of fry. As an experiment, artificial heat was applied to the water in the supply tank with the view to maintaining an even temperature of 68° in the jars; but this plan was soon abandoned, as it would have been impracticable to hold the fry in artificially heated water until that in the sound reached the same temperature.

The distribution of the fry commenced on April 21, and at the close of operations 5,647,000 had been planted, also 1,811,000 eggs. The remaining 2,194,000 eggs were transferred to Central Station.

Shad-hatching operations on steamer Fish Hawk in Albemarle Sound in 1897–98.

Date.	Shad.	Eggs taken.	Mean temperature of water.	Date of hatching.	Number hatched.
Mar. 28	6	147,000	62		
29	28	462,000	62		
30	22	557,000	61		
31	14	339,000	57		
Apr. 1	8	182,000	55		
2	28	569,000	56		
5	4	77,000	54		
6	6	129,000	53		
7	8	123,000	54	Apr. 8	1,126,000
8	4	131,000	55		
9	46	719,000	55		
11	6	122,000	56	Apr. 11	382,000
12	20	398,000	57		
13	36	772,000	59	Apr. 13	71,000
14	30	713,000	59		
15	34	633,000	58		
16	44	695,000	59		
18	58	991,000	59	Apr. 18	115,000
19	30	644,000	58	Apr. 19	600,000
20	20	415,000	61		
21	50	995,000	62	Apr. 21	150,000
22	12	546,000	61	Apr. 22	561,000
23	40	932,000	62	Apr. 23	189,000
				Apr. 24	713,000
25	44	1,043,000	65	Apr. 25	1,027,000
				Apr. 26	713,000
Total	398	12,334,000			5,647,000

On April 26, after the plants had all been made, the vessel proceeded through the Chesapeake and Albemarle Canal to Norfolk, en route for Delaware Bay, to resume the hatching of shad at that point.

Delaware River, Steamer Fish Hawk.

The vessel arrived at Gloucester, N. J., on May 3, and at once commenced the collection of eggs from the seines fished in Howell Cove, Riverton, and other points between Gloucester and Philadelphia, over 2,000,000 being secured the first night. Work continued uninterruptedly until May 11, when operations were cut short, as the Navy Department called for the services of the vessel in connection with the Cuban blockade. During this short period over 12,433,000 eggs were secured, but, owing to the unusually cold weather prevailing and the consequent low temperature of the water, many of them died in the jars. The 5,342,000 remaining when work was discontinued on the 11th were transferred to the Pennsylvania State hatchery at Bristol, Pa., together with the hatching apparatus and such boats and launches belonging

to the vessel as were needed for conducting operations at that point. The vessel was then taken to the League Island navy-yard, Philadelphia, and turned over to the Navy Department.

BRISTOL STATION, PENNSYLVANIA (G. H. TOLBERT IN CHARGE).

Anticipating the probable detail of the *Fish Hawk* to duty under the Navy Department, tentative arrangements had been made early in the spring with the State Fish Commission for the use of their hatchery on the Delaware River, and as soon as it was learned definitely that the vessel was to leave the service of the Commission, Mr. G. H. Tolbert, fish-culturist at large, was instructed to proceed to Bristol and prepare the hatchery for the reception of eggs. The hatchery is a two-story frame building, and is equipped with 120 McDonald jars and a good steam plant. Immediately upon the arrival of Mr. Tolbert the necessary employees were taken on and, with the assistance of the crew of the *Fish Hawk*, everything was in readiness for the commencement of work by May 13. A small force of spawn-takers was employed to attend the seines between Bristol and Riverton, and work proceeded uninterruptedly till the end of the month, 10,848,000 eggs being secured from the seines at Riverton, 1,841,000 from North Cramer Hill, and 220,000 from Dutch Neck and Badger Island. In addition to the 5,342,000 eggs turned over by the *Fish Hawk*, 3,095,000 were transferred from Battery Station, making a total of 21,346,000 handled at this point during the spring. These yielded 15,460,000 fry, which were liberated during May and June in the Delaware River and its tributaries. At the close of operations on June 10 the temporary employees were discharged, and the hatchery turned back to the State Fish Commission. The results would indicate that under more favorable conditions and by the employment of a larger force, from 30,000,000 to 40,000,000 eggs might be collected here during the spring.

BATTERY STATION, MARYLAND (ALEXANDER JONES IN CHARGE).

Anticipating an early run of shad on account of the mild weather in March, preparatory work commenced sooner than usual, and by April 10 the station was in readiness for active fish-cultural operations. The temporary force of 36 employees was taken on between that period and the middle of the month. To encourage the collection of eggs by the fishermen, two spawn-takers were stationed at Havre de Grace to receive and care for all taken in that vicinity, and four men were detailed on a schooner in Northeast River to obtain all that were available at that point. Spawn-takers were also stationed as usual at the seines fished at Carpenter Point and on Osmond's float below Havre de Grace. The remainder of the force worked the boats from the station and accompanied the launches on the nightly trips to the various fields.

Eggs commenced coming in on the 13th of April, and by the end of that month 105,364,000 had been secured; the collections during one night amounted to 22,539,000. The largest number of shad eggs ever collected in the Commission heretofore within twenty-four hours was a little over 8,000,000, in the spring of 1888, at this station. The take

in April exceeded the total number ever secured at any of the shad stations of the Commission in a single season, the largest heretofore recorded being 105,125,000 at Battery during the year referred to above. Work continued uninterruptedly until June 9, the collections in May aggregating 95,510,000 and in June 9,118,000, making a total of 209,992,000 for the season. Of these, 140,337,000 were purchased from fishermen at $20 per 1,000,000; the balance was taken by the regular spawn-takers. The capacity of the hatchery was severely taxed from the beginning of the season on account of large collections during the first ten days, but the pressure was partly relieved by transferring eggs to Central Station, Washington. Car No. 3 was equipped as a hatchery and stationed at Perryville. The low temperature prevailing at this time, however, retarded development to such an extent that the hatchery was soon filled to overflowing, and it became necessary to plant large numbers of eggs on the spawning-grounds.

Table of shad-hatching operations at Battery Station.

Date.	Eggs received.	Eggs hatched.	Eggs shipped and planted.	Fry planted.	Date of hatching.	Temperature of air.	Temperature of water.
						°	°
Apr. 13	203,000				Apr. 23		53.5
14	676,000						
15	2,338,000						
16	706,000		1,939,000				
17	5,909,000	655,000	2,541,000	655,000	30	56.5	54.5
18	15,230,000	6,244,000	7,233,000	6,244,000	May 1	52.5	51
19	10,916,000	2,152,000	8,118,000	2,152,000	2	52.5	51
20	432,000						
21	8,285,000	70,000	5,891,000	70,000	3	52.5	51
22	2,507,000		2,410,000				
23	11,631,000	4,227,000	3,219,000	4,227,000	5	54.5	53
24	13,747,000	4,212,000	9,395,000	4,212,000	7	54.5	53
25	22,539,000	4,155,000	13,552,000	4,155,000	9	54.5	53
26	8,432,000	880,000	3,947,000	880,000	9	53.5	53
27	529,000		300,000				
28	328,000						
29	956,000						
May 1	956,000	434,000		434,000	10	55.5	53.5
2	1,407,000	850,000		850,000	10	55.5	53.5
3	13,674,000	8,555,000		8,555,000	10	55	53.5
4	15,588,000	2,605,000	12,093,000	2,605,000	11	55	53.5
5	18,230,000	1,315,000	16,045,000	1,315,000	12	56	56
6	3,685,000	1,360,000	1,103,000	1,360,000	13	56.5	57
7	1,056,000	360,000		360,000	14	58	58
9	401,000	25,000		25,000	May 15	59.5	58
10	2,066,000	1,515,000		1,515,000	15	64.5	54.5
11	1,892,000	1,570,000		1,570,000	16	64.5	61.5
12	1,665,000	1,335,000		1,335,000	16	64.5	62.5
13	2,374,000	1,377,000		1,377,000	17	65.5	63.5
14	1,402,000	596,000		596,000	18	64.5	63.5
15	2,066,000	1,318,000		1,318,000	20	69.5	65.5
16	2,204,000	1,563,000		1,563,000	21	70	72
17	3,451,000	2,185,000		2,185,000	22	70	66
18	5,337,000	3,625,000		3,625,000	23	70	62
19	1,974,000	1,090,000		1,090,000	24	70	62
20	4,950,000	4,625,000		4,625,000	26	71	67.5
21	1,439,000	1,395,000		1,395,000	26	66	67.5
22	4,214,000	3,691,000		3,691,000	27	66	64
23	2,061,000	1,628,000		1,628,000	28	67	68
24	1,124,000	927,000		927,000	29	66.5	66
25	517,000	179,000		179,000	31	67	68
26	90,000	80,000		80,000	31	67	68
30	1,687,000		1,635,000		June 1	67.5	71
June 1	1,196,000	1,078,000		1,078,000	5	70.5	70
2	2,380,000	2,150,000		2,150,000	7	71	72.5
3	1,508,000	400,000	1,051,000	400,000	8	72	72.5
4	1,147,000	100,000	972,000	100,000	9	77	74
5	999,000	900,000		900,000	10	77	74
6	968,000	895,000		895,000	11	77	73.5
7	920,000	900,000		900,000	11	77.5	76
Total	209,992,000	73,221,000	91,444,000	73,221,000			

The weather was very cold during the early part of the season, the temperature from April 13 to 30 varying from 48° to 58°. About the middle of May it rose above 60° for the first time since collections commenced. These conditions, though not unfavorable to the collection of eggs, were unfavorable to their development. Many lots were held from 12 to 16 days before hatching, and the fry resulting from them were not only weak, but the percentage hatched was very small.

Particular attention was paid during the season to the spawning habits of the shad, with the view to ascertaining the character of river bottom most frequently resorted to in depositing their eggs. The investigations seemed to show that at the head of the Chesapeake Bay they prefer flats covered by débris, such as sticks and trees, and this theory accounts to some extent for the frequent changes of the spawning-grounds. The most successful fishermen select such places when in search of ripe fish, the collection of eggs forming an important part of their income late in the season, when fish sell for very little.

Attention is again called to the fact that large numbers of eggs of excellent quality were taken in the day—that is, from 4 a. m. to 4 p. m.

In addition to the eggs hatched at Perryville on car No. 3 and those transferred to Central Station, several shipments were made to Bristol, Pa., and, though sent in June, when the weather was quite warm, they hatched without material loss. Heavy losses were reported, however, on the shipments transferred to Central Station early in the season.

Striped bass were quite abundant during the spring, and some ripe ones were found. Two small lots of eggs were brought to the station, but they proved defective. A number of measurements were made of them, and in every instance they were found to be 0.125 inch in diameter.

In addition to the fish-cultural work, various repairs were made to the buildings, boats, and dock; 45 cases of herring roe were canned as fish food to be used at Wytheville and Craig Brook, and 3 half-barrels were salted for the same purpose.

The mean temperatures for the months of April, May, and June were: April, air 52°, water 50.5°; May, air 63°, water 62°; June, air 72°, water 72.8°.

Bryan Point Station, Maryland (L. G. Harron in charge).

During the summer and fall a hatchery with a capacity for 40,000,000 shad eggs was erected, under the direction of Mr. G. A. Schneider, at an expense of $1,000. The building is a one-story frame structure, 61 feet by 31 feet, and is equipped with six hatching-tables 16 feet long by 3 feet wide, and two tables 14 feet long by 3 feet wide, the larger tables carrying 32 jars each and the smaller ones 24.

Arranged around the sides of the building are rows of shelves for carrying eggs in open jars during the early stages of development, and fry tanks for holding the fry until they are ready for shipment. A commodious office and storeroom have been fitted up at the east end. The erection of this hatchery necessitating an increase in the pumping plant, a Worthington pump, of a capacity of 620 gallons per minute,

was transferred from Cape Vincent, N. Y., and the necessary water and steam connections were made during the winter by the engineer in charge. In addition to these improvements, a sea wall 140 feet long was built along the north side of the hatchery to protect it against the encroachments of the river.

In March preparations were commenced, under the direction of Mr. L. G. Harron, for fish-cultural work. A part of the force was taken on, and the steam launch *Blue Wing*, which had been rebuilt during the year, was placed in commission and transferred to the station. Tents were erected as usual for the accommodation of the crew, and by April 15 the station was ready for the reception of eggs. A few eggs came in on the 15th, 16th, and 17th, but the full force was not taken on until the 18th. The personnel, including the crew of the steam launch *Petrel*, which was also utilized for this work, consisted of 20 spawn-takers, 6 assistants in hatchery, 1 clerk, 8 men for the launches, 2 firemen, and 2 cooks. Operations were much interfered with throughout the season by severe storms and unseasonable weather. Heavy northeast gales occurred on April 20 and 27, accompanied by snow and rain, which stopped all work for several days. The laying of submarine mines on some of the best spawning-grounds in the vicinity of Forts Washington and Sheridan also curtailed collections considerably, and the establishment of the blockade at Fort Washington made it impossible to secure any eggs between there and Alexandria, as the launch was unable to go up and down the river at the proper times. The catch of fish was small, but the work was pushed so vigorously that by May 26 the total collections amounted to 68,724,000, nearly as many as were ever taken on the river. Of these, 4,448,000 were sent to Central Station; from the balance 47,366,000 fry were hatched and planted in the Potomac River between Broad Run and Occoquan Creek.

At the close of the season the temporary force was discharged, the station dismantled, and the launches transferred to other points.

With the experience gained this year it is believed that the collections at this station can be very materially increased and the work can be much more economically conducted with the new hatchery.

The following table shows the maximum, minimum, and mean temperatures of air and water from April 15 to May 25, inclusive:

April 15 to 30.	Air.	Water.	May 1 to 25.	Air.	Water.
Maximum	83	59	Maximum	88	73
Minimum	34	51	Minimum	52	55
Mean	59	55	Mean	69	63

CENTRAL STATION, WASHINGTON, D. C. (J. E. BROWN IN CHARGE).

As usual, all of the product of the Fish Commission ponds was distributed through this station, and consignments of lake trout, brook trout, Loch Leven trout, rainbow trout, and landlocked salmon eggs were transferred from other stations and hatched here, to illustrate the fish-cultural methods employed by the Commission.

The following table shows the number of eggs received and of fry hatched and distributed:

Species.	Number shipped.	Lost in transit.	Number hatched.
Loch Leven trout	9,950	98	7,282
Lake trout	25,000	239	22,140
Brook trout	10,000	72	8,556
Rainbow trout	10,000	38	7,948
Landlocked salmon	5,000	1	4,996

A larger amount of freight was handled during the year than usual, owing to the preparation of exhibits for expositions at Omaha, Nebr., and Bergen, Norway, 312 packages being received and 264 shipped out in addition to the regular freight and exclusive of the equipment belonging to the car and messenger service, which is stored here.

It having been determined to discontinue the hatching of shad eggs at this station on account of the construction of a hatchery at Bryan Point, the apparatus was dismantled and a portion of it transferred to Bryan Point, but the large collections necessitated the utilization of the station to a certain extent for this work. In April 1,525,000 eggs were received from the *Fish Hawk* at Avoca, N. C.; over 15,000,000 came in from Battery Station between April 20 and May 1, and 4,044,000 were sent up from Bryan Point. Owing to lack of facilities it became necessary to deposit 5,179,000 of the eggs in the Potomac River. The balance were hatched and the fry were planted in the Potomac except 3,537,000 which were transferred to the Fish Commission ponds.

AQUARIUM, CENTRAL STATION, WASHINGTON, D. C. (L. G. HARRON IN CHARGE).

The superintendent of the aquarium was detailed for duty at the Nashville Exposition from July 1 to September 14, and in March was placed in charge of the shad operations at Bryan Point, Md., where he remained until the end of May. He was again detached from duty in June and ordered to Omaha, where he remained until the close of the fiscal year.

As there was considerable difficulty in keeping the marine fish in healthy condition the salt water, which had been in use for several years, and which had received additions of artificial salt water from time to time, was discarded during the summer. The tanks were thoroughly cleansed and 6,000 gallons of salt water were brought from the Chesapeake Bay, in the vicinity of Old Point, Va. The usual collections of salt-water fishes were made in October at Old Point, 571 specimens, representing 33 species, being successfully transferred to the aquarium. The collection was further increased by consignments of sea-anemone and lobsters from Gloucester, Mass. All of these specimens, except a few which were bruised in transit, remained in the tanks to the close of the fiscal year. The only salt-water fishes that spawned during the year were two flounders, but the eggs did not hatch.

No difficulty was experienced in holding bass, goldfish, golden ide, and other fishes common to the Potomac River during the summer, and

in November consignments of brook trout, Scotch sea trout, steelhead trout, rainbow trout, quinnat salmon, Atlantic salmon, Atlantic salmon domesticated, and landlocked salmon were received from Craig Brook and Wytheville stations. These were carried until April 30 without material loss, when a heavy mortality ensued through the use of an excessive amount of alum in filtering the water. A few hundred of the rainbow, steelhead, and brook trout were saved, but they succumbed in June, when the water temperature reached 81°.

The large-mouthed black bass on hand at the close of the fiscal year have been in the aquarium for two years. When transferred from the Fish Commission ponds in June, 1896, they were between 2 and 3 inches long. They now measure from 9 to 12 inches.

The exhibit this year has been much more satisfactory than for several years previous, owing to the renewal of the salt-water supply and the installation of a large filter, which affords an abundance of clear water for the fresh-water specimens. The *Salmonidæ*, the basses, and most of the salt-water species are fed principally on round beefsteak, but their diet is varied from time to time by the use of live minnows.

The following is a list of the marine and fresh-water fishes and crustaceans exhibited during the year:

Marine species.	Marine species.	Fresh-water species.	Fresh-water species.
Croaker.	Pinfish.	Large-mouth black bass.	Goldfish.
Sea bass.	Black drum.	Small-mouth black bass.	Yellow perch.
Swellfish.	Dog shark.	Rock bass.	Sunfish.
Spadefish.	Red drum.	Brook trout.	English tench.
Tautog.	Spotted sea-trout.	Scotch sea trout.	White sucker.
Toadfish.	Pigfish.	Steelhead trout.	Chub sucker.
Sea-robin.	Pompano.	Rainbow trout.	Channel catfish.
Hog-choker.	White perch.	Quinnat salmon.	Yellow catfish.
Bluefish.	Burfish.	Atlantic salmon.	Leather carp.
Kingfish.	Star-gazer.	Atlantic salmon, demesticated.	Scale carp.
Blenny.	Scup.	Landlocked salmon.	Common eel.
Lizard-fish.	Lobster.	Crappie.	Paradise fish.
Spot or goody.	Blue crab.	Golden ide.	Mill roach.
Jumping mullet.	Spider crab.	Golden tench.	Tadpole.
Yellow-tail.	Hermit crab.		Terrapin.
Moonfish.	Shrimp.		Snapping turtle.
Flounder.	Diamond-back terrapin.		
Striped bass.	Sea-anemone.		

FISH COMMISSION PONDS (DR. R. HESSEL, SUPERINTENDENT).

As large numbers of young bass were destroyed by the *Notonecta* and the *Ditiscus* during the spring and summer of 1896, the crop available for distribution in the fall was smaller than that of the previous year, though operations had been conducted on a larger scale. During September and October 14,222 large-mouthed bass, 1,837 small-mouthed bass, and 779 crappie were shipped.

Early in April the breeding bass were transferred from the retaining-ponds to the spawning-beds in the north and south ponds and Nos. 6 and 7, the south pond being devoted exclusively to the small-mouthed variety. Artificial nests were placed in convenient places, and also piles of gravel for making natural nests. The first nests with eggs were discovered in the south pond on April 26, and on the following day a number of nests containing eggs were noted in the north pond.

Fry were observed within three or four days, and by the end of the month the fish had nearly finished spawning. The temperature during this period varied greatly, but the results were not injurious, apparently, as only four nests appeared to be affected with fungus.

The following shows the temperature of water on the spawning-beds from April 20 to 30, inclusive, taken at 7 a. m. and 4 p. m:

Date.	North pond.		South pond.		Date.	North pond.		South Pond.	
	7 a. m.	4 p. m.	7 a. m.	4 p. m.		7 a. m.	4 p. m.	7 a. m.	4 p. m.
	°	°	°	°		°	°	°	°
Apr. 20	58	64	58	58	Apr. 26	59	58	59	59
21	54	61	54	60	27	55	54	54	56
22	54	60	50	60	28	47	48	48	49
23	58	66	58	66	29	48	49	52	53
24	64	67	62	68	30	50	51	50	52
25	63	65	62	55					

As soon as the schools of young bass dispersed they were allowed to pass from the spawning beds to the main ponds, and the adults were again transferred to the stock ponds. The young fish were fed, as usual, on carp and tench reared for the purpose, from 400,000 to 500,000 carp a few days old and a large number of tench being placed in the north and south ponds during the season. At the close of the fiscal year the indications were that the crop of bass would be large, but it was impossible to form any definite idea of the number in the ponds on account of the dense growth of algæ.

In October the shad placed in the west pond during the previous spring were liberated in the Potomac River as usual.. The number released was estimated at about 3,000,000. In May, 1898, another consignment of 3,537,000 were put in the same pond to be reared.

Some attention was paid this season to the propagation of frogs. A number of adults were placed in Pond 19 during the spring, and at the close of the year there were 4,000 young ones. Their hind legs had developed, but the fore legs were not yet visible. They were taking food freely. The old frogs live on bumble-bees, dragon-flies, ordinary flies, beetles, and moths that come within their reach over the grass borders. A number of the tadpoles were transferred to the aquarium in Central Station, and it was found that they would take cornmeal readily. It is intended to continue these experiments in the future in the hope that some useful information may be gained with reference to the culture of frogs in ponds.

The pond which had been stocked with fresh-water shrimps from North Carolina was examined during the fall of 1897 and 5,400 were found. Twenty-five of them were removed to a tank in the greenhouse and were carried through the winter in excellent condition. No trace of the others could be found in the spring, and it is thought that they were killed by the severe frosts.

Notwithstanding the efforts during the past two years to eradicate injurious plants and insects from the ponds by drawing off the water

and exposing the bottoms to frost, the condition of the north and south ponds was worse this year than ever before. The muddy sediment on the bottom was removed during the fall to a depth of 5 inches, and though a careful examination of the soil in March seemed to indicate that every trace of the injurious material had been removed it appeared in larger quantities than heretofore.

WYTHEVILLE STATION, VIRGINIA (GEORGE A. SEAGLE, SUPERINTENDENT).

Operations at this station were confined chiefly to the propagation and distribution of rainbow trout. In September the superintendent was detailed to make an investigation in Georgia for the selection of a suitable site for a fish-cultural station. This work, with reports, etc., occupied his entire time for that month. At the beginning of the fiscal year the stock of brood-fish on hand was as follows:

Species.	Calendar year in which fish were hatched.				
	1897.	1896.	1895.	1894.	1893 or before.
Rainbow trout	181,000	2,000	870	515	2,300
Quinnat salmon	4,200				
Black bass, small mouth				12	
Black bass, large mouth			34	26	
Rock bass					145
Crappie					45

Of the rainbow trout, 61,000 fry were distributed during July and August, and the balance, 110,000, in November and December. These fish were carried during the summer in the rearing troughs and ponds, and fed on a mixture of beef liver and mush. About 12 pounds of this food were fed daily to 1,000 adult fish, and about $\frac{3}{4}$ pound to the same number less than a year old. The adults were fed twice a day, half of the above-stated amount being given at each feed. The small fry were fed four times a day on liver and mush, canned herring roe, and salted cod roe alternately. They were first trained to take the canned herring roe, and their diet was then varied by salted cod roe and liver. If the fry are first given the liver, it is afterwards difficult to induce them to take the roe.

In July, 1897, small samples of a prepared food, believed to be dried shrimp ground up, was sent to the station on trial by Mr. A. Voight, of Brooklyn, N. Y. The material in one parcel was finely ground, that in the other was coarser. Both samples were fed to the fingerlings, as there were none smaller at that time. The fish took no notice of the finely ground food, but of the coarser probably half was consumed. It is believed that small trout could be trained to take this food, and that it would be wholesome for them, though, perhaps, too expensive for use.

Of the total stock of adult fish, only 503 females produced eggs during the year. The spawning season commenced earlier than usual—on November 8—and continued until February 10. The total number of the eggs collected was 410,000, an average of 815 per spawner; for the fertilization of these, 320 males were used. The loss of eggs, owing to

imperfect fertilization and to other causes, was 23 per cent of the total number taken. Of the eyed eggs, 190,000 were shipped to foreign applicants and transferred to other stations; the remaining 124,000 were hatched at the station.

In April and May all of the fry on hand were transferred to Erwin Station, Tennessee, in order that the work of remodeling the ponds and making additions to the hatchery might be commenced.

In the spring the adult black bass and rock bass were placed in the spawning-ponds, but, owing to their poor condition, it is doubtful whether any results will be secured.

At the close of the season the stock of fish on hand was as follows:

Species.	Calendar year in which fish were hatched.				
	1898.	1897.	1896.	1895.	1894 or before.
Rainbow trout	6,446	3,450	844	700	1,500
Black bass, small mouth					7
Black bass, large mouth		45		34	20
Quinnat salmon	2,500				
Crappie				170	
Rock bass					85
Carp					20

In the fall the volume of water flowing from the spring decreased to such an extent that a loss of 800 two-year-old rainbow trout was sustained. As it was believed that the water escaped through subterranean passages, an effort was made to stop this waste by making a cut in front of the spring and filling it with stone and cement. At some points it was necessary to dig down 15 feet. The holes and sides were then tightly packed with clay, and the ditch filled with stone laid in cement. The wall thus formed was 4 feet thick at the bottom, 2 feet at the top, and capped with a cut stone 6 inches. As a result an increase of 100 gallons of water per minute was obtained.

The title to the station property having been satisfactorily adjusted during the winter by the legislature of Virginia, the appropriation of $10,000, made by Congress in 1896, became available in March. The work of repairing and remodeling the ponds was at once commenced, and by the end of June nineteen ponds had been constructed and the old residence removed.

ERWIN STATION, TENNESSEE (S. G. WORTH, SUPERINTENDENT).

On August 4 Mr. S. G. Worth, who had been appointed superintendent of the station, took charge, relieving Mr. W. F. Hill, who had been in charge of the construction. Work on the hatchery, dwelling, and ponds was pushed vigorously during the summer, and on October 20 the hatchery building was turned over to the Commission by the contractors. During the fall the troughs were constructed and placed in position, and in December the water supply was turned on in the hatchery. The large ponds at the station having been completed in November, arrangements were immediately made for collecting wild brook trout from streams in the vicinity for brood stock.

During November and December 2,989 fish, ranging from two to four years old and from 5 to 13 inches in length, were obtained and delivered at the station without loss at an expense of $367.80. No difficulty was experienced in making this collection, as numbers of streams within 40 or 50 miles of the station are well stocked with trout. As an illustration, in Higgins Creek, about 12 miles southwest of Erwin, 600 were taken in a stretch of less than 2 miles. The fish collected were hauled across the mountains to the station in wagons, and though many of them were en route two days but one fish was lost. They were placed in the large ponds, and though examined frequently no eggs were secured. It is presumed that the ripe fish spawned on the gravel bottom around the springs boiling up in the bottom of the pond.

The exact number on hand at the close of the year is not known, but many were lost. It is believed that the mortality was largely due to the depredations of cats, to which the brook trout, lying during the night in shallow water near the shore, fell an easy prey. The wounds were usually found on the back of the neck near the gill-covers and on the sides as far back as the first dorsal fin. The cats, when discovered to be enemies of the fish, were killed.

In February 100,000 brook-trout eggs were received from East Freetown, Mass., and although the loss during incubation and the early fry stages was apparently small, when the fish were transferred to the ponds on June 9 there remained only 11,562 by actual count.

During December 1,826 yearling rainbow trout were received from Wytheville and placed in one of the ponds. These fish have not done well, quite a number having died during the season; a large proportion have become very dark in color, and many of them are blind. The eyes protrude gradually, and are sometimes seen outside of the socket. The fish are apparently in good condition otherwise, fat, and without external wounds. No explanation of this condition can be furnished, but there is an impression among the people in the vicinity that rainbow trout have a tendency to become blind when introduced into the large springs of this section.

Two well-authenticated cases have been reported: General Wilder placed 14 adult rainbow trout obtained from Wytheville in a large spring near Elizabethtown, Tenn., and in a short time every one was blind. Another lot, placed in a large spring near Erwin, suffered the same fate. The blindness among the station fish occurred in ponds which had springs at the bottoms. The brook trout were not affected in this way except in a few instances where they worked their way into the reservoir; all fish entering the reservoir showed these symptoms, and died. The presence of minerals in the water may cause this difficulty, but it more probably results from the settling of air bubbles or grit on the mucous coating of the eyeballs. The water contains an immense amount of air, bubbling from the springs and buoying up the fine gravel and sediment unnaturally in the water. The reservoir water always contains sediment in suspension.

During the winter 50,000 rainbow-trout eggs were received from Wytheville. These were hatched, and on April 23 there were on hand 21,200 fry. In addition to these, 81,300 rainbow-trout fry were transferred from Wytheville during the month of April and held in troughs until June 7, when they were transferred to ponds, and were found by actual count to have been reduced to 51,899. There remained on hand at that time, from all sources, 73,099. At the close of the year all of the fish were doing well, though those transferred from Wytheville were much smaller than the station fish. It is believed that a considerable number of the fry were destroyed by snakes. As soon as their presence was suspected a temporary fence was placed around the ponds; in a week 5 water-snakes had been killed, and over 100 were killed during the year.

Much difficulty was experienced during the winter in procuring a sufficient amount of suitable food. All of the beef liver available in Erwin and Johnson City was purchased at prices varying from 5 to 8 cents per pound, but the supply was uncertain, and in April arrangements were made for securing regular supplies from Armour & Co. in Norfolk, Va. Whenever the shipments failed a mush, consisting of flour, eggs, sorghum, water, and salt, was used.

In the coldest weather, with snow and ice on the ground, the air was swarming with mosquito-like insects. There are also myriads of aquatic worms on all objects in the water here, and several varieties of *Gammarus* were seen in the supply ditch when the loose mud was being thrown out, though none have been noted in the ponds. Snails are exceedingly abundant, and the trout seem to feed on them; as they reproduce at an enormously rapid rate, there will probably always be plenty of food of this character.

The principal aquatic plant known in this region is the so-called branch lettuce, which spreads its roots under the shallow water or in wet mud. This remains green throughout the winter. During the cold season its leaves lie flat on the water, like lily pads, but in summer the seed stalks rise to the height of 2 feet. The submerged leaves and branches serve as nurseries for periwinkle and other lesser forms of animal life. Quantities of wood or leaf mold were used for the purpose of disinfecting the ponds and establishing natural conditions. In order to procure natural food for the larger fish a lantern with metal wings, to lure beetles and moths, was placed in the pond; striking the metal walls, the insects fall upon the water and become an easy prey for the trout. While the supply of food thus derived has not been great, better results are looked for during the summer and fall, when such insects will be very plentiful. When the water was turned on in the temporary pond built in the bed of the branch, which had been lined with mud, myriads of jointed red worms, about half an inch in length, were seen at the bottom, massed together here and there.

The temperature of the water in the spring is 55° throughout the year. In the ponds there is a variation of from 55° at the bottom to

71° at the surface. During the winter, though the temperature of the air reached zero, no ice was formed in the reservoir, ponds, or ditch.

During the spring the station grounds were overrun with stray dogs and cats, and with a view to checking this influx all of the discarded food was buried. This measure apparently had no effect, and it became necessary to destroy all intruders of this character found on the grounds. Frogs of all kinds were also abundant, and it became necessary to destroy many of them. The food frogs were removed from the station grounds and placed in a stream below the railroad. In May and June tree frogs were spawning in large numbers in the ponds. Kingfishers were often observed, although few were killed. Snapping turtles were noticed occasionally while the ponds were being excavated, but not in great numbers. The miller's thumb is abundant.

While engaged in the construction of the station the superintendent was the recipient of valuable assistance from residents in the vicinity, officials of the Ohio River and Charleston Railroad, Mr. Dana Harmon, attorney-general of the first Tennessee district, and Mr. P. L. Haun, sheriff of Unicoi County, through whose cooperation the collection of wild trout from the streams of eastern Tennessee was made possible, as the laws of the State forbid the capture of trout during the fall months.

Put-in Bay Station, Ohio (J. J. Stranahan, Superintendent).

With the view to increasing the collection of whitefish eggs on Lake Erie, for restocking the waters of this lake and supplying the hatcheries on Lakes Ontario, Huron, and Superior, it was determined, in addition to collecting eggs, as heretofore, from the nets fished in the western end of the lake, to pen large numbers of male and female fish and hold them until ripe, as it was believed that, if this method proved feasible, the collections of eggs would be limited only by the number of fish caught. Under the old system severe gales during the height of the spawning season reduced the collections from 30 to 50 per cent, notwithstanding the fact that nearly as many fish were caught over the same area as usual, and though nearly the same amount of money was expended in the work. Arrangements were made with a number of fishermen in the vicinity of Put-in Bay and Bass Islands to obtain the fishes desired, holding them in crates until the close of the season, when they were to be returned to the fishermen.

During October, when we had anticipated securing many fish, the weather was so unfavorable that they did not arrive on the spawning-grounds for at least two weeks later than usual, and none were secured until November 8, and these were taken under adverse circumstances. Collections continued until November 27, when all of the nets were removed. The total number secured was 1,247, and 1,119 of these were transferred to live-boxes or crates. Of the 334 females, 260 were available as spawners and produced 10,269,000 eggs, an average of 39,496 to the fish. The balance of the females were "plugged" or died from injuries. The disproportion of sexes was due to the fact that large numbers of males were penned early in the season on the suppo-

sition that the later run would contain more females than males. The eggs secured from the penned fish were of fair quality, though not as good as those collected during a favorable spawning season. With the experience gained there is little doubt that in the future much larger and better results will be secured. The eggs collected from the penned fish cost $1.20 per quart, or $3\frac{1}{6}$ cents per 1,000; those taken directly from the fish captured in the usual manner cost less than 2 cents per 1,000. This is exclusive of the cost of the live-boxes, pens, nets, etc., which are on hand and available for work in the future. It is easily understood that ten times as many eggs could have been collected at the same expense as the number referred to, in which event the cost would have been less than 1 cent per 1,000.

The following is a brief description of the methods employed in collecting and penning the fish and of the apparatus used: Stationary live-boxes, supported by piling, have often been used, but as the water at Put-in Bay becomes too warm for this, the boxes were made so that they could be towed, like a raft, into open waters where the current is more vigorous and the temperature more uniform; another advantage gained by this method is that an equal depth of water is maintained in the live-boxes, the rise and fall in this section varying from 4 to 5 feet in a single day, according to the direction and velocity of the wind and the atmospheric pressure. The boxes are 16 feet long, 8 feet wide, and 8 feet deep, divided into two equal compartments 8 feet square, provided with false bottoms controlled by standards running in guides at the ends. The standards are pierced by inch holes at intervals of 6 inches, so that the false bottoms may be held at any desired place. The lumber used was 6-inch pine boards planed on the inside and nailed to scantling $1\frac{1}{4}$ inches apart, so fastened together as to make every side interchangeable. The six boxes, divided into twelve compartments with a capacity for 4,500 fish, were fastened at the ends to boom logs 65 feet long, with plank walks on both logs, thus permitting free access to all parts of them.

Owing to the difficulty experienced in transferring the fish from the pound nets to the boxes, on account of rough weather, supplemental nets 7 feet long and 3 and 4 feet in diameter were placed at each pound net where fish were expected; these were held open at top and bottom by iron rings, and the bottoms were provided with puckering-strings for closing them. By fastening one side of these nets to the down-haul stake and the opposite one to the rim of the pot of the pound, the upper ring is held 3 feet above the surface of the water and the lower one 4 feet below, serving as a weight to keep the net down and also to keep it open, so that the fish will have plenty of room and not be scaled by chafing against the net. Thus located, the supplemental net is in convenient position for receiving the fish when the pound is lifted. By the use of these nets it became possible to secure many more fish than otherwise. During the past season fish were collected from six sets of nets with an equal number of boats, aggregating 55 pound nets. An employee of the Commission was placed in each boat, to dip out the fish

and put them in the supplemental nets, and also to collect the eggs from ripe females. The dip nets used for taking the fish from the pounds have long handles and hoops of spring steel, and are covered with heavy open cloth such as is used in the cider press, as the knots and twines of the ordinary net would injure the scales of the fish.

The steamer visited the supplemental nets daily when the weather permitted, and removed the fish to spacious tanks on board, then transferring them to the station, where they were counted and assorted. It is necessary to exercise much care in this work, as success is entirely dependent upon the fish reaching the live-boxes uninjured. Before placing them in the boxes they are assorted into three classes—soft, medium, and hard. The soft ones (those nearly ripe) are examined each day; the medium every third or fourth day, and the hard ones at the end of each week. In this way much unnecessary handling is avoided and the fish are kept in good condition. At the close of the season all were returned to the fishermen in excellent condition.

Spawn-taking is conducted under a temporary shelter erected on a raft, and does not differ materially from the mode generally pursued. The last fish were removed from the live-boxes on December 13, when six of them were placed in one of the fry-tanks at the station for future experiment. One of these was what is known as a "plugged" female; that is, her abdomen remained hard and showed a congested condition. This specimen was killed and opened. The ovaries were found to be congested and the eggs, when examined under the microscope, all showed ruptured yolks. Two of the other fish were apparently healthy females containing spawn, and two were healthy males. These were held in the fry tanks until December 21, when the females were found to be ripe. In fact, one of them had cast most of her eggs in the tank. From the other nearly a quart of spawn was taken.

The eggs were fertilized with milt from one of the males and presented a very good appearance, though it was noticed that they were a little undersized, running 10 to the linear inch instead of 8. The temperature of the water at the time being 32.5°, the eggs did not show distinct segmentation at the end of the first 24 hours, and they were not therefore critically examined until they were 48 hours old, when it was discovered that 90 per cent of them were impregnated, but over half of them seemed abnormal, the discs being spread out more than usual and many being segmented in patches or clusters. They were again examined on the 24th, and it was found that 10 per cent of them plainly showed well-defined twin discs, and three triplicate discs were discovered out of some 500 eggs examined. They were kept under observation from day to day, and micrographs taken. It was also observed that there were many eggs in this lot containing insufficient yolk-sacs. This led to an examination of several other lots of eggs taken late, which in turn revealed the fact that the late eggs contained a much larger percentage of insufficient yolks than those taken earlier in the season. It has been noticed each season since this station was established that the late eggs did not turn out as well as those taken at the

PLATE XIII.

1. Unfertilized whitefish egg 24 hours old.

2. Fertilized whitefish egg 6 hours old, geminal discs forming, no segmentation having taken place.

3. Whitefish, 12 hours, showing first cleavage. Water 38°.

4. Whitefish eggs, 18th hour. Water 38°, showing second segmentation, four cells formed

5 Whitefish egg 24 hours. Water 38°.

6. Whitefish egg 48 hours. Water 38°

DEVELOPMENT OF THE WHITEFISH EMBRYO

7 Fertilized whitefish egg 72 hours old, showing segmentation well advanced

8. Whitefish egg, seventh day, embryo beginning to show.

9. Whitefish egg 43 days old, showing embryo.

10. Whitefish 90 days old, showing embryo.

11. Whitefish egg, yolk-sac ruptured by rough handling, 24 hours old

12. Whitefish egg with triple discs

DEVELOPMENT OF THE WHITEFISH EMBRYO

13. Whitefish egg, showing twin discs, 3 days old

14. Whitefish egg, showing twin discs, 6 days old.

15. Whitefish eggs, showing twin discs, 7 days old.

16. Whitefish eggs showing twin discs, 8 days old.

17. Whitefish egg, showing twin discs, 13 days old.

18. Whitefish egg, showing twin discs, 15 days old.

DEVELOPMENT OF THE WHITEFISH EMBRYO.

19. Double-headed whitefish fry just hatched.

20. Double-headed whitefish fry.

21. Curved spine, a common deformity of whitefish fry.

22. Whitefish fry just hatched, three-eyed, curved spine

23. A common deformity of whitefish fry.

24. Four-eyed whitefish fry.

DEVELOPMENT OF THE WHITEFISH EMBRYO.

height of the season. It may be stated that no twin discs were found among the other lots examined, although after the above experience it had been confidently expected to find them. Never before, however, has a twin disc been observed in a whitefish egg, and only three were found this season outside of the lot under consideration; neither have twins or double-headed monstrosities been found common among the whitefish fry, though they are common among the lake trout.

The development of this lot of eggs was watched with much interest, but on January 10, when the embryos began to form, not a single twin or double-headed one could be found. It was observed, however, that 20 per cent of the eggs were far behind the rest in point of development and, though apparently alive and healthy, there was no sign of embryotic formation. This went on until January 26, when two well-defined double-headed embryos were discovered. From this on they were found in numbers, though very few of them had two perfect heads, and there were no well-marked twins—that is bodies entirely separated except by their attachment to the yolk-sac, as is so common with trout. Most of the monstrosities had one normal and one abnormal head. It is worthy of note that the perfect head was, without a single exception, on the left side, and where both were abnormal the left one was the better of the two, as will be noted in the accompanying micrographs.

Since writing the above Superintendent Stranahan has learned, by consultation with Prof. Jacob Reighard, of the University of Michigan, that in his opinion the large number of abnormalities found among these eggs was caused by their being held long past the normal time of deposit. His experience showed that this is likely to be the case with amphibians held in confinement. This may furnish the reason why late eggs show more monstrosities than those taken early in the season.

The penning of whitefish near the station this season has afforded exceptional opportunities for experiment with the fertilization and development of the ova, and considerable attention has been paid to the determination of how long milt will retain its vitality after being mixed with water. On December 4 a quantity of spawn, just as it was taken from the fish, was brought to the station, and a small quantity placed in each of 16 perfectly dry, clean pans, which were set in running water at a temperature of 36°. The milt of three males brought alive to the station in a tub of water was taken in a dry pan, care being exercised that no water dripped from the fishes into the pan. Water was then added, and a portion poured into one of the pans containing eggs, numbered 0. In a quarter of a minute another portion was poured into the pan numbered 1, and so on to the finish. After each lot had stood one minute the eggs were washed and placed in kegs in running water, with numbers to designate each lot. On December 5, the eggs, being well segmented, were carefully examined under the microscope, to determine the percentage of impregnation. In each case those with ruptured sacs, or those destitute of germinal disks were not taken into account, the object being to determine the percentage of impregnation at the different periods.

The following table shows the percentage of impregnation in each lot:

Time.	Per cent.	Time.	Per cent.	Time.	Per cent.	Time.	Per cent.
0 minute	99	1 minute	93	2 minutes	14	3 minutes	7
¼ minute	98	1¼ minutes	77	2¼ minutes	18	3¼ minutes	3
½ minute	99	1½ minutes	47	2½ minutes	8	3½ minutes	2
¾ minute	96	1¾ minutes	19	2¾ minutes	6	3¾ minutes	2

On December 8 the experiment was repeated with, if possible, more care than on the previous occasion. It was carried further, to determine the point at which absolute loss of vitality would take place. The following table shows the result, the temperature of the water being 35.5°:

Time.	Per cent.	Time.	Per cent.	Time.	Per cent.	Time.	Per cent.
0 minute	98	1¼ minutes	49	2½ minutes	14	3¾ minutes	1
¼ minute	97	1½ minutes	2	2¾ minutes	15	4 minutes	0
½ minute	83	1¾ minutes	42	3 minutes	1	5 minutes	0
¾ minute	82	2 minutes	11	3¼ minutes	0	6 minutes	0
1 minute	83	2¼ minutes	14	3½ minutes	1	7 minutes	0

It will be seen that the eggs fertilized 1½ minutes after water was added to the milt showed but 2 per cent alive, while those affected by the next period, a quarter of a minute later, showed 42 per cent. Although great care was taken to avoid mistakes, it is evident that there was one in this case, or that something in the pan caused the death of a great number of these eggs.

It frequently occurs that large numbers of eggs are lost during the latter part of the season, owing to the scarcity or entire absence of males when large numbers of ripe females are taken. To overcome this difficulty, experiments were conducted to determine how long milt and eggs could be carried alive separately and then fertilized. The milt of 5 males was taken in a vial which had been rendered chemically clean and dry. Great care was exercised in taking the milt, and to avoid the mixture of water, excrement, or other foreign substances, the mouth of the vial being held up close to the vent of the fish, and only such portion taken as came in a stream. The vial was then tightly corked and placed in running water in a pan, so as to secure a temperature as nearly that of the fish as possible. This milt was taken at 10.45 a. m. on December 4. On the following day, at the same hour, a small amount of eggs was fertilized with this milt. An examination showed that the percentage of impregnation was as complete as would naturally be the case with fresh-taken milt. A series of experiments of the same character was continued for several days, the eggs being kept in clean pans in running water, light being excluded. All the milt was treated as the first lot, precautions being taken not to let water enter the vials when the corks were removed.

The following table is self-explanatory. In making the counts, all eggs with ruptured yolk-sacs or those destitute of germinal discs were disregarded, the object being to determine the percentage of impregnation. The examinations were as carefully made as practicable, 100 eggs impregnated and unimpregnated being counted for each lot below referred to.

On December 8 six lots were examined, as follows:

Date of examination.	Lot.	Date and hour of taking.		Date and hour of impregnation.	Per cent.
		Spawn.	Milt.		
Dec. 8	First	Dec. 7, 9.20 a. m	Dec. 4, 10.45 a. m	Dec. 7, 9.25 a. m	95
	Second	Dec. 6, 11 a. m	Dec. 6, 11.25 a. m	Dec. 7, 9 a. m	97
	Third	Dec. 6, 11 a. m	Dec. 4, 10.45 a. m	Dec. 7, 9 a. m	98
	Fourth	Dec. 7, 8.45 a. m	Dec. 7, 8.45 a. m	Dec. 7, 9.10 a. m	98
	Fifth	Dec. 6, 11 a. m	Dec. 7, 8.45 a. m	Dec. 7, 9.10 a. m	93
	Sixth	Dec. 7, 8.45 a. m	Dec. 6, 11.25 a. m	Dec. 7, 9.25 a. m	85
Dec. 9	First	Dec. 6, 11 a. m	Dec. 4, 10.45 a. m	Dec. 8, 1.15 p. m	3
	Second	Dec. 6, 11 a. m	Dec. 6, 11 a. m	Dec. 8, 1.15 p. m	91
	Third	Dec. 8, 1.20 p. m	Dec. 4, 10.45 a. m	Dec. 8, 1.25 p. m	6
Dec. 12	First	Dec. 11, 2 p. m	Dec. 6, 11.25 a. m	Dec. 11, 2.10 p. m	3
	Second	Dec. 6, 11 a. m	Dec. 11, 2 p. m	Dec. 11, 2.20 p. m	0
	Third	Dec. 11, 2 p. m	Dec. 9, 9 a. m	Dec. 11, 2.05 p. m	0
	Fourth	Dec. 11, 2 p. m	Dec. 4, 10.45 a. m	Dec. 11, 2.15 p. m	0
	Fifth	Dec. 11, 2 p. m	Dec. 7, 8.45 a. m	Dec. 11, 2.10 p. m	0

From these experiments it would seem that neither spawn nor milt retain their fertility after the third day; but this is not necessarily the case, as the milt used in all of these long-time experiments, with one exception, was from the lot of December 4, which had been repeatedly uncorked and possibly injured by the admixture of a small amount of water, while the spawn was held in small lots of a half pint or less, which were more liable to dry out than a large mass. All of the eggs used in this experiment, except one lot, were placed in a jar marked "miscellaneous," and examined from time to time, showing a good percentage of impregnation. Before being placed in the jars they were held separately in kegs for two or three days with running water and reexamined to observe if the development seemed natural, and no difference could be seen between these and eggs of the same age taken at the same time in the usual manner. It is a matter of regret that there were not enough taken at one time to fill a jar, so that they could have been carried separately up to the hatching period.

An experiment was also tried with a view to hatching whitefish eggs with closed circulation—that is, using the water over and over. The water was pumped into a 12-gallon keg, whence it descended by gravity to the jar, thence to a large tin vessel, which was partially submerged in running water in order to maintain a low temperature. From this it was again pumped back to the keg. This experiment was continued for 13 days without damage to the eggs, although, owing to the fact that the temperature of the water was 7° warmer than that taken from overboard, the development was much more rapid. It may also be stated that so much oil was carried over from the pump that it formed a considerable coating on the surface of the water in the receiving vessel, also on the inside of the jar. The eggs, however, were apparently not injuriously affected by this circumstance. These eggs hatched before any others in the house, and the fry were apparently as healthy.

Collections of eggs were made, as heretofore, from the commercial fishermen, but owing to the unfavorable conditions prevailing during November, the total collections amounted to only 112,842,000 whitefish and 27,786,000 cisco or lake herring. From the nets fished in the vicinity of Port Clinton, 40,653,000 whitefish eggs were obtained; from

those in the vicinity of Toledo, 21,348,000; North Bass Island, 21,762,000; Middle Bass field, 2,331,000; Kelly Island, 7,866,000; Catawba Island, 720,000; from Put-in Bay, 18,000,000 whitefish eggs and 27,786,000 of the eggs of the cisco; from other points, 162,000 whitefish eggs. Of these eggs, 10,000,000 were transferred to Alpena Station; the balance were hatched and distributed during March and April on the spawning-grounds from which the eggs were collected, the cisco fry being planted in the vicinity of Put-in Bay.

During the winter 1,000,000 lake-trout eggs were received from Northville, which were hatched and planted in the vicinity of the station.

It having been determined to resume the propagation of pike perch, steps were taken to secure a force of spawn-takers and arrangements made with the fishermen for attending the pound nets in the vicinity of Put-in Bay, Toledo, and Port Clinton. The warm weather in March raised the temperature of the water to 42.5°, which advanced the spawning season a week. The first eggs were taken on March 31, earlier than ever before in the history of the station. A small lot was brought in by the fishermen in this neighborhood. The regular spawn-takers were not put on until April 4. On April 5 a severe northeast gale set in, accompanied by snow, the temperature falling from 42.5° to 38°. This not only interfered materially with the work, but the eggs taken were poor. The weather continued unfavorable throughout the spawning season, gale following gale in rapid succession, which not only seriously reduced the collections, but affected unfavorably the work in the hatchery. The water pumped at the station was loaded with dirt, causing much extra labor and continual handling of the eggs. Dead eggs, which ordinarily fungus in a few days and are drawn off, were coated with dirt so that they were of the same weight with the others, and failed to rise to the top, necessitating not only constant handling, but the passing of the eggs through fine screens, in order to remove those which were fungussed.

As a result of the season's work, 221,062,500 eggs of poor quality were collected; 87,112,000 from the Toledo field, 111,900,000 from the Port Clinton field, and 22,050,000 from the vicinity of Put-in Bay.

In the beginning of the season starch was used to prevent adhesion of the eggs; but complaints were received from every section that this material was not satisfactory, as was proved by the fact that all of the eggs came to the station more or less adherent. Swamp muck, which had been used with success three years before, was substituted and sent out at once but, owing to delays en route the season was nearly over at Toledo before it could be used. Not more than 2 tablespoonfuls of the muck solution to 5 gallons of water was needed to prevent adhesion. Experience has also shown that it is advisable to put the muck in the water in the keg in which the eggs are poured after impregnation, rather than to mix it with the eggs in the pan prior to fertilization. If a small amount of water is added to the eggs immediately after fertilization and the milt washed out quickly, adhesion does not take place for a minute or two.

On April 16, near the close of the season, one of the spawn-takers, Mr. Carl Rotert, was directed to remilt the eggs taken on that date; that is, to add fresh milt one minute after first applying it to the eggs, and to add a third lot a minute later. In all, 450,000 eggs were treated in this way, and after careful examination under the microscope, at the expiration of twenty-four hours, out of the three lots of 150,000 each not an unimpregnated egg could be discovered. They were then put in a jar and kept thus to the close of the season. After the ruptured eggs had worked off (ruptured eggs fungus and separate from the good ones much sooner than the unimpregnated ones) the jar stood in striking contrast to the balance of the eggs in the house, a solid mass of living eggs. For some unaccountable reason they hatched before any of the others, though taken last. Instead of requiring several days to hatch, they all came out together, and the fry were apparently healthy, as seen under the microscope or with the naked eye. It is a matter of regret that this experiment was not tried earlier in the season, as it appeared from the results attained in this instance that previous heavy losses on pike-perch eggs may have been largely due to imperfect fertilization. This matter will receive attention next season, and experiments will be tried in remilting whitefish eggs also.

The eggs collected at Toledo were shipped on trays by the steamers running from Cleveland to Toledo three times a week, and although the eggs were held at least two days on the trays, they were apparently not injured by the shipment; 30,000,000 of the pike-perch eggs were transferred to Cape Vincent hatchery, and in order to decide as to the best method for long-distance shipments, a part of them were transferred on trays, and the balance in the ordinary transportation cans filled with water. Of those transferred on trays, only 30 per cent hatched, while of those shipped in water 75 per cent hatched. As eggs were successfully shipped on trays from Toledo to Sandusky, it appears that the loss must have been due to concussion, caused by the jolting of the cars, the eggs on trays being much more subject to this than those in water.

On May 2 it was observed that the eggs seemed unusually buoyant, and that they rose higher in the jars than usual with the same amount of water. Examination under the microscope revealed the existence of numerous colonies of infusoria, nearly every egg having one or more colonies. They were in the main a species of *Carchesium*, with a few *Vorticella*. These being lighter than the water, and offering considerable resistance to the current, floated the eggs. On the 3d they had increased to such an extent that it was necessary to put the eggs into tubs and thoroughly wash them. This process broke the slender threads which connect the individual infusoria to their main stem on the egg, and remedied the evil. Later it was found that by thoroughly feathering the eggs in the jar the same results could be secured. These animals were found in all the jars, there being no difference whether muck or starch had been used. Thorough investigation did not show that the eggs were damaged, directly or indirectly, by these infusoria.

Owing to the unfavorable conditions above enumerated, only 71,110,000 fry were hatched. These were planted in the waters of Lake Erie at the following points:

Point of deposit.	Number.	Point of deposit.	Number,
Peach Island reef	13,500,000	Niagara reef	10,320,000
North Bass Island reef	7,320,000	West Sister Island reef	10,320,000
Ballast Island reef	6,000,000	Rattlesnake Island reef	12,900,000
Middle Bass Island reef	10,750,000		

It is believed that the daily examination of eggs under the microscope will prove to be an important factor in the future operations of the station, as it is thus possible to keep track of the work of individual spawn-takers, poor results being very frequently due to carelessness in handling the eggs. The superintendent made photomicrographs of the normal impregnated egg showing segmentation, of the unimpregnated egg showing the germinal discs with no nodules of segmentation, and of an egg with ruptured yolk-sac, destroyed by rough handling. These were sent to the spawn-takers, so that they could understand how easily the three classes of eggs are distinguished one from the other under the microscope.

During the year a number of improvements were made to the grounds and in the adjacent harbor. A sea wall, 115 feet long and from 4 to 6 feet high, was constructed on the south side of the hatchery parallel with the shore line, and the space back of it filled in with dredgings from the lake bottom in front. The ground was graded and seeded and beds of plants set out, improving greatly the appearance of the station. The space adjacent to the docks was also dredged out, so that the steamer could come in and out at low water, and also to provide sufficient space for wintering the vessel.

The following table gives the maximum, minimum, and mean temperatures of air and water in the hatchery during the year:

Month.	Air.			Water.			Month.	Air.			Water.		
	Max.	Min.	Mean.	Max.	Min.	Mean.		Max.	Min.	Mean.	Max.	Min.	Mean.
1897.							1898.						
July	98	65	78.44	82	71	76.90	January	55	11	30.87	33.25	32.5	32.58
August	82	62	70.2	81	68	72.8	February	58	—4	28.45	32.5	32.5	32.5
September	84	51	62.6	73.5	62	68.2	March	64	20	40.30	42.5	32.5	35.57
October	76	44	56.93	65	54	55.7	April	63	23	45.53	49	38	43.95
November	55	22	37.71	54	36	41.5	May	75	44	60.74	66	48.5	56.90
December	54	11	29.82	37.5	32.5	33.57	June	89	60	72.15	75	64	70.23

NORTHVILLE STATION, MICHIGAN (F. N. CLARK, SUPERINTENDENT).

During the summer the station employees were occupied in improving the grounds, painting and repairing the fish-cultural apparatus, and caring for the fish on hand. Early in September the lake trout carried through the summer were distributed in Lakes Huron, Michigan, Superior, and interior lakes. As the cars of the Commission were occupied at other points at this time, the distribution was made by means of a baggage car, obtained through the courtesy of the officials of the

Flint and Pere Marquette Railroad. Although the fish were planted without loss, the use of baggage cars for this purpose under ordinary circumstances is not deemed advisable, as they are not equipped for transportation on fast trains.

Early in August the superintendent visited the important fishing centers on Lakes Superior, Huron, and Michigan to make arrangements for the fall work. As a law had recently been passed by the State legislature prohibiting all fishing for lake trout and whitefish between November 1 and December 15, no efforts were made to secure eggs of the latter species. Messrs. H. H. Marks and George Platts were put in charge of the field operations, as the regular foreman, Mr. S. W. Downing, had been detailed to assist in the salmon work on the Pacific coast.

The first lake-trout eggs collected were received at Northville on September 16, but as the temperature was unusually high at the time of shipment they proved a total loss. Eggs continued to arrive all through October and until November 8, most of them being in excellent condition. The shipments aggregated 12,014,000, over 5,000,000 of which were taken in the Georgian Bay. Of the balance, 4,938,000 were obtained from the fisheries on the north shore of Lake Michigan near Manistique, within a period of ten days, 500,000 from the southern and 992,000 from the northern shore of Lake Superior.

The results from Lake Superior were disappointing, as large collections had been expected from that section. No efforts were made to attend the fisheries at Beaver Island, one of the most productive sections in past years, as the trout in that vicinity do not spawn usually before November 1. Letters received from fishermen during the latter part of October, however, indicated that large numbers of spawning fish had made their appearance, and it is possible that many eggs can be secured there in the future during the closing days of that month. The eggs were packed in cases and forwarded from the field stations direct to Northville by freight, as usual, one of the employees meeting the boat on its arrival at Detroit. Shipments of eyed eggs, aggregating 4,535,000, were made between October 9 and December 28 to other stations of the Commission, State fish commissions, and foreign applicants, 1,500,000 of this number being sent to the Alpena hatchery. The eggs commenced hatching early in December, and on January 1 a carload of fry was deposited in the Straits of Mackinac. No other shipments were made until February, when 3,492,000 were disposed of. A few of these were given to private applicants and the remainder deposited at various points in the Great Lakes, on the natural spawning-grounds.

It was intended to carry the balance of the fry (250,000) until fall, but the tanks became so overcrowded in May that it became necessary to distribute 50,000 of them. These had made a remarkable growth during the three months they were retained in the troughs, and when planted they were 3 inches in length. At the close of the year there remained on hand 160,244 fingerlings, the average weight of which was $4\frac{7}{8}$ pounds per 1,000.

As the stock of brood-fish of the brook trout at the station was very small, arrangements were made with the Michigan Fish Commission to make collections on the Au Sable River. A field station was opened on that stream late in September, and under the direction of Mr. A. T. Stewart 10,000 fish were captured, chiefly by means of seines, hook and line being used only where they were scattered. They were confined in two ponds, and during the fall 516,400 eggs were obtained from them and transferred to Northville, the shipments being so arranged as not to hold the eggs longer than the eighth day, as experiments in 1895 demonstrated that they could be moved with safety up to that time. The eggs collected at this point were not so good as those taken from the brood-fish at Northville, and cost about $1 per 1,000 delivered at the station.

From the two-year-old brood-fish 128,350 eggs were obtained, 304 females yielding an average of 422 each. The fry commenced hatching early in December, and on February 3 a shipment of 100,000 was sent to the Au Sable. Various other plants were made from time to time until March 23, the total distribution aggregating 228,000. At the close of the year there remained on hand 15,000 fingerlings, their average weight being $6\frac{1}{8}$ pounds per 1,000.

The Loch Leven trout commenced spawning October 15, and from that time until the 27th of November 74,525 eggs were collected from 75 females. The eggs were of poor quality, due, it is thought, to the advanced age of the fish. Shipments aggregating 25,000 were made to private applicants; the balance were hatched, and at the close of the year there were 4,715, of an average weight of $2\frac{3}{16}$ pounds per 1,000. There are also 2,969 two-year-old fish in stock, which will spawn during the coming season.

The steelhead fingerlings on hand at the commencement of the year were retained at the station until March, 1898, when 3,500 were planted in the Pere Marquette River and Cold Creek, and 200 of them were transferred to the Omaha Exposition. It is intended to rear the balance for breeders, as an experiment. These fish did not attain as great a growth as the rainbow, Loch Leven, or brook trout raised under the same conditions, but reports from various sections in which plants have been made indicate the capture of quite a number of specimens measuring from 10 to 12 inches, especially in the Pere Marquette River. None of these specimens have so far been identified, however. On April 19 a shipment of 95,880 eggs was received from Fort Gaston, Cal. These were hatched, and the 75,000 fry resulting from them were planted during the month of May in Little Manistee River, Manistee County, near Grand Rapids, Mich., and various streams tributary to Lakes Huron and Michigan.

A few breeding black bass transferred to this station two years ago are still in stock. They spawned early in June, but as there were no suitable ponds for the reception of the fry, no efforts were made to rear them.

PLATE XVII.

DULUTH HATCHERY.

The following table shows the number of fish on hand at the close of the year:

Species.	Calendar year in which fish were hatched.				
	1898.	1897.	1896.	1895.	1894 or before.
Brook trout	15,600	1,412	1,200		
Loch Leven trout	4,715	2,967		293	16
Lake trout	160,244				
Steelhead trout	7,000	910			
Rainbow trout		800			
Black bass		124	80		
Total	187,559	6,213	1,280	293	16

ALPENA STATION, MICHIGAN (FRANK N. CLARK, SUPERINTENDENT).

In addition to a number of minor repairs made during the summer, a new floor was laid in the hatchery, the batteries were rebuilt, and new tanks were purchased and installed. This work was directed by Mr. W. W. Thayer, in the absence of Mr. S. W. Downing, the foreman. No special efforts were made to collect whitefish eggs, owing to the passage of a law prohibiting fishing from November 1 to December 15, but 480,000 were obtained from fishermen in the vicinity; 10,000,000 were also transferred from Put-in Bay during the month of December. The fry commenced hatching on April 7 and finished April 16. The entire lot was planted in Lake Huron with the exception of 500,000 deposited in Clear Lake.

Attention is called to the following instance, as indicating to what extent whitefish eggs may increase in bulk after having been placed in the hatching-jars. On November 15 a spawn-taker secured 56 ounces of eggs from one whitefish, as measured 10 hours afterward. They were placed in a jar by themselves and left undisturbed until March 7 except to clean off the dead ones, when they were again measured and found to contain 64 ounces.

In addition to the whitefish hatched at the station 1,500,000 lake-trout eggs were transferred from Northville. These were hatched in February and the fry resulting from them were planted in March at various points on Lakes Huron and Michigan.

Mr. Downing returned to the station on October 26 and remained in charge until the close of the year, when the hatchery was dismantled and the hatching apparatus cleaned, painted, and put away for the season.

DULUTH STATION, MINNESOTA (S. P. WIRES, SUPERINTENDENT).

During the summer 240 fry troughs, 7 feet 5 inches long, 11 inches wide, by 7¾ inches deep, were constructed for the lake-trout work; the grounds in front of the hatchery were plowed, partially graded, and the old carp ponds filled in; repairs were made to the supply tank and hatching-room, and the flume leading from Leslie River, which had been damaged by freshet during the past summer, was rebuilt.

The lake-trout season opened the middle of September and closed the 9th of November, 7,007,000 eggs of excellent quality being secured from the following points:

Locality.	Number.	Locality.	Number.
Port Caldwell, Ontario	800,000	Long Point, Isle Royale, Mich	740,000
Port Arthur, Ontario	2,346,000	Grand Portage, Minn	260,000
Little Todds Harbor, Isle Royale, Mich.	460,000	Washington Harbor, Isle Royale, Mich.	800,000
Fishermen's Home, Isle Royale, Mich.	475,000	Ontonagon, Mich	1,000,000
Siscowet Bay, Isle Royale, Mich	126,000		

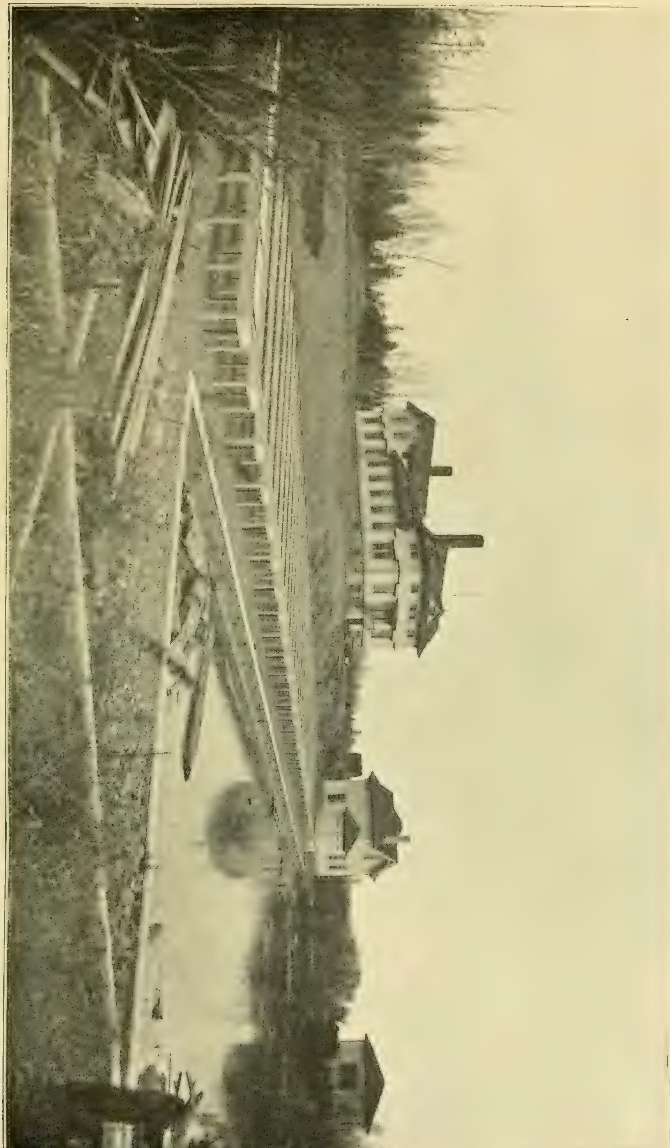
A shipment of 480,000 eyed eggs was transferred to the Manchester Station; the balance were hatched and deposited on the spawning-grounds where the fish were captured, the distribution extending from early in April to June 22. The output amounted to 5,143,000 and the total loss of eggs and fry to 1,384,000.

An effort was made to collect whitefish eggs in the neighborhood of Port Arthur, but only 200,000 could be secured prior to the close of the fishing season on November 1. Spawn-takers were also sent to Basswood and Crooked lakes, Minnesota, but no eggs were obtained. Many fish were captured at these points, but no ripe ones were found, which indicated that the fishing in the vicinity is not on the spawning-grounds. The eggs obtained at Port Arthur were of poor quality and yielded only 98,000 fry; these were planted near Isle Royale.

During January 100,000 brook-trout eggs were received from Leadville, from which 92,550 fry were hatched and planted in the waters of Minnesota and South Dakota. Consignments of steelhead eggs, amounting to 150,000, arrived from Fort Gaston in April. They were of good quality and produced 130,000 fry, which were liberated in suitable streams emptying into Lake Superior.

MANCHESTER STATION, IOWA (R. S. JOHNSON, SUPERINTENDENT).

As soon as the appropriation of $4,216 became available, work on the buildings and grounds was resumed, under the direction of the superintendent. During the summer and fall of 1897 and the spring of 1898 three large stock-ponds were excavated and graded, the ponds being connected with wooden flumes to get a circulation of water from one to the other. Owing to the large amount of sand in the soil, it was afterwards found necessary to line the bottom of one of the ponds with clay; but the results were not satisfactory. Seven large rearing-ponds, 80 by 20 feet, were graded and the sides lined with 2-inch hemlock plank. The bottoms were covered with clay, and on this was spread 4 inches of muck. They were arranged in tiers, so that the water could pass from the upper ones into the lower. Twenty-four small rearing-ponds, 7 by 22 feet, were constructed in a similar manner, and twelve existing ponds of the same kind, previously lined with stone, were remodeled and wood lining substituted. Connections were also made from the lower reservoir for supplying the large and small rearing-ponds. In order to avoid a recurrence of damage from freshets,



DULUTH HATCHERY, NURSERY TROUGHS, AND STOREHOUSE.

the wagon-bridge was raised 1½ feet and extended 20 feet, a new stone abutment being built on the west side of the branch; the roadway was raised to the same height and a dry stone wall built along the road to prevent washouts.

For the protection of the 14-inch water-supply pipe and ponds a dry stone wall was also built along the spring branch. All of the grounds around the buildings and ponds were graded and terraced, and roadways were built from the main entrance to all the buildings and ponds. These roadways were graded and bedded with gravel, and surface gutters of stone were provided. The necessary fences were also erected alongside the country road from the Fish Commission reservation to the main highway, and all of the lands were sown with blue grass and white clover. An hydraulic ram, for forcing water to the dwelling, mess-house, and barn, was placed in the hatchery. All of the dead timber on the reservation was cleared up and converted into stove wood. An orchard, consisting of assorted apple, cherry, plum, and pear trees, blackberry, raspberry, currant, and gooseberry bushes, strawberry plants, and grapevines, was set out south of the dwelling-house.

As soon as the ponds had been completed, in the latter part of October, arrangements were made to collect brood-fish from open waters in the State. Supplies of large-mouth and small-mouth black bass, rock bass, crappie, and rainbow trout were obtained from the rivers in the eastern part of Iowa. All of the breeding-ponds were planted with *Ceratophyllum*, *Elodea*, *Ranunculus*, water lily, and other aquatic plants, and artificial nests and piles of gravel were located at suitable points in the three large stock ponds and in the 80-foot rearing-ponds. The spawning-beds were partitioned off with inch-mesh wire netting, so that the young fish, by passing out into the main ponds, might escape the depredations of the adults.

The small-mouth bass placed in Pond Z began nesting on the gravel beds on May 2, and a number of nests were observed between that time and June 1. The first fry appeared on May 24, and though quite a large number of nests were seen the indications are that the crop will be small, owing to the difficulty of keeping the ponds full of water and to the absence of the natural food necessary for very young fry.

The large-mouth black bass collected from the Maquoketa River and in the vicinity of Quincy, Ill., suffered severe losses during the winter, owing to injuries received in transportation. In the spring 180 remained on hand, which were placed in Ponds X and Y. The majority of these fish spawned on mud bottoms, only a few of them using the gravel, and in no instance were the artificial nests occupied. The first eggs were noted on May 11, but no fry were observed until June 1. At the close of the spawning season the adult fish were removed from the breeding-ponds, so as to give full range to the fry. No effort was made to determine the exact number on hand at the close of the year, but it is believed that the results will be good, notwithstanding the fact that owing to the very scanty growth of aquatic vegetation natural food is not as

abundant as it should be. The maximum temperature of the water in these ponds between April 1 and June 1 was 78°; minimum, 48°.

In the spring the 180 adult crappie remaining were placed in three of the 80-foot ponds. They were observed nesting on May 11, and though a number of nests were noticed between that time and June 4 no young fish were discovered.

A supply of rock bass was also placed in one of the 80-foot ponds. They commenced to spawn about the middle of May, and at the close of the year several schools of young fish were seen in this pond.

In addition to the rainbow trout on hand at the beginning of the year, 1,000 yearlings were received from Neosho in November. These arrived in excellent condition and were placed in the ponds with the others to be reared. In January and February two consignments of eggs, amounting to 44,720, were received from Neosho, which produced 30,364 fry. Of these, 4,000 were distributed to applicants in Iowa and 26,363 remained on hand at the close of the year. During the fall 85 2-year-olds and 74 yearling rainbow trout were collected from one of the streams in the vicinity of the station and added to the brood stock.

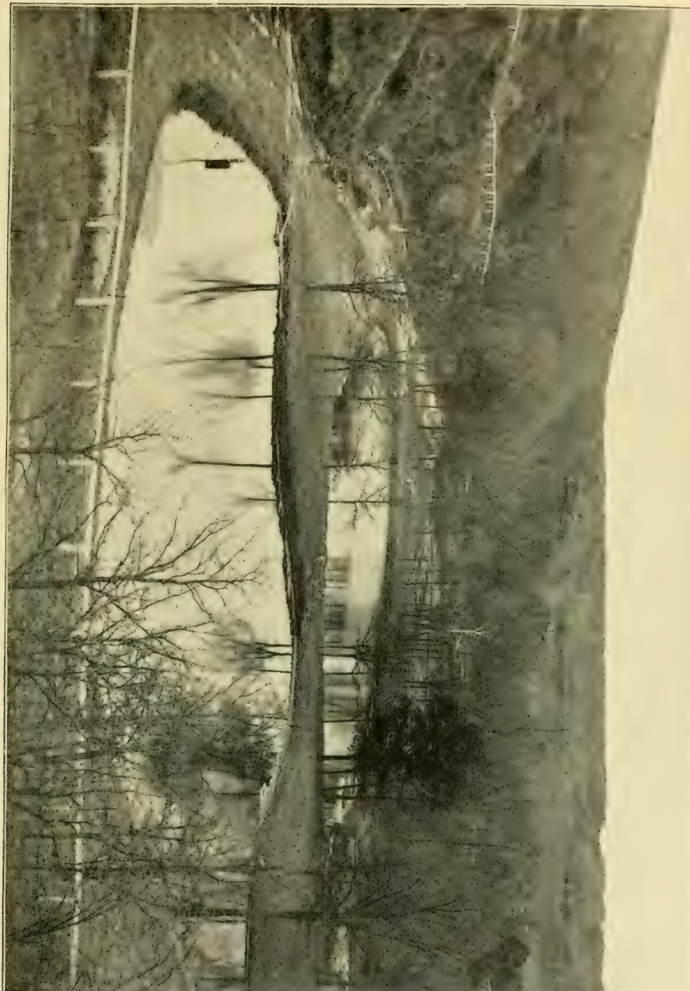
All of the brook-trout streams in the eastern and northern parts of the State were examined during the summer, with a view to making collections of eggs and brood-fish, but at no point could sufficient numbers be found to justify the expense of establishing a field station for the collection of eggs. 513 adult trout were secured, which yielded 38,592 eggs during October. In addition to these, 100,000 brook-trout eggs were purchased in Massachusetts, which arrived in excellent condition in January and produced 83,700 fry. During the spring 19,000 brook-trout fry were distributed, and at the close of the year there remained at the station 79,595 fry. Consignments of 480,000 lake-trout eggs from Duluth and 50,000 grayling from Bozeman were transferred to this station. The lake trout arrived with a loss of only 723; subsequent losses, amounting to 42,600, occurred, however, during incubation.

The fry which resulted from these eggs, amounting to 437,000, were planted in public waters during the spring, with the exception of 400 which were held for experimental purposes. The grayling eggs, which arrived in fair condition, hatched in June with a loss of 8,710. They appeared to be strong and healthy, though it is difficult to induce them to take artificial food.

The stock on hand at the close of the year was as follows:

Species.	Calendar year in which hatched.			
	1898.	1897.	1895.	1894.
Brook trout	79,595		288	198
Rainbow trout	26,365	3,396		
Lake trout	400			
Grayling	50,000			
Loch Leven trout			41	
Large-mouth black bass				175
Small-mouth black bass				38
Rock bass				24
Crappie				179

PLATE XIX.



BASS PONDS AT MANCHESTER, IOWA.

It is believed that large numbers of young black bass and crappie could be collected from the overflowed lands along the Mississippi River in the vicinity of Bellevue, Iowa, and it is recommended that investigations be made with the view to establishing a collecting station at that point.

QUINCY STATION, ILLINOIS (S. P. BARTLETT, SUPERINTENDENT).

The spring of 1897 opened with cold rains, which continued at frequent intervals until July, and apparently affected the spawning of black bass in the vicinity of Meredosia, as very few fry were observed. Great difficulty was consequently experienced in making the usual collections; even at the commencement of operations the fish captured from the overflowed ponds and lakes measured from 5 to 7 inches in length, showing they had hatched the previous year. As the season advanced the weather became extremely hot and dry, and continued so until late in October, making it difficult to transfer fish from the ponds to the station.

As a result of the operations for the season 25,139 black bass and 3,468 crappie were delivered to the cars for distribution.

The weather conditions during the spring of 1898 were much more favorable, the rivers being high early in the spring and remaining in that condition long enough for the bass and other fish to deposit their eggs in the interior lakes and sloughs. While engaged in collecting two carloads of fishes in Meredosia Bay in May and June for the Omaha exposition, large numbers of young bass were observed, and 5,000 were easily caught and transferred to the ponds at the station.

The property at Meredosia is in good condition. The buildings were painted during the year, the grounds seeded, and other steps taken to improve the appearance of the station.

NEOSHO STATION, MISSOURI (H. D. DEAN, SUPERINTENDENT).

At the beginning of the year 90,725 rainbow-trout fry were on hand, but losses occurred during the summer and fall, which reduced the number for distribution in October to 75,850. Of these, 72,850 were deposited in public and private waters, 2,000 were retained for brood stock, and 1,000 were transferred to Manchester Station. The brood stock on hand consisted of 1,580 three-year-olds, 311 four-year-olds, and 209 from five to ten years old. From 321 ripe females three years of age a total of 188,320 eggs was secured, an average of 586 each; 154 of the old fish produced a total of 216,815, an average of 1,400 per fish. Of the former, only 43 per cent were good; of the latter 58 per cent.

The first eggs were secured in December, and collections continued from that time until March 1, the total take amounting to 405,435. Of these, 207,814, or 51 per cent, were eyed. At the close of the year there remained on hand 92,200 fry, 14,000 having been distributed in April and May.

The poor quality of the eggs may be attributed to some extent to the fact that the fish were kept during the spawning season in ponds with-

out raceways; consequently it was necessary to handle them daily in order to select the ripe ones.

Of the 11,326 black bass on hand in July, 10,151 were distributed during the fall. The distribution was very successfully accomplished, the loss amounting to almost nothing. During the summer it was noticed that one trough of fish in the hatchery were not doing well. They were transferred to another trough in the spring branch which was supplied with warm water, and in a few days they were thriving. In October 100 of the adult bass collected from Meredosia Bay were transferred to the station. They were placed in the ponds, and were taught in a few days to take artificial food: At first fish cut in large pieces was fed to them along with minnows; after a short time the minnows were omitted, liver being mixed with the cut fish, and a few days later they were taking liver and beef without trouble. When the pond was drawn in March, 98 of this lot remained.

Owing to the roily condition of the water during the spring, spawning was observed in only one instance. Large numbers of fry were seen in the ponds later, but no attempt was made to transfer them, as the water contained an abundance of natural food. Contrary to the usual practice, the ponds were kept full of water during the winter, and at the spawning time they were abundantly supplied with vegetation and insect life. A few young fish were transferred to the hatchery for experimental feeding, and no difficulty was experienced in teaching those over half an inch in length to take food.

When the distribution of rock bass was made in the fall, 13,618 fish remained of the 14,850 on hand in July. In the spring, when the pond was drawn to prepare it for the breeders, 1,950 young bass were taken out which must have hatched there late in the fall. Spawning occurred at the usual time and numbers of young fry appeared later.

The results of last season's work with strawberry bass and crappie, though not so large as had been hoped for, were the most successful so far attained at the station. Of the 10,630 fry on hand from the hatch of the previous spring, 56 per cent, or 5,962, were distributed in the fall. It is very difficult to handle these fish in warm weather, and it is also hard to teach them to take food. In the spring 62 strawberry bass were placed in pond 14 and 11 crappie in another pond.

The following table shows the number of fish on hand at the close of the year, and the maximum, minimum, and mean temperatures to which the various species were subjected:

Species.	Calendar year in which hatched.			Temperature to which subjected.		
	1898.	1897.	1895.	Max.	Min.	Mean.
				°F.	°F.	°F.
Rainbow	92,200	1,974	1,200	75	46	58.34
Black bass	....	95	198	91	32	60.79
Rock bass	....	1,950	92	89	36	58.25
Crappie	....	....	11	87	32	59.10
Strawberry bass	....	71	60	90	33	58.22

The following table shows the air and water temperatures and the amounts of rain and snow as recorded by months:

Month.	Max.	Min.	Mean.	Precipitation.	Snow.	Month.	Max.	Min.	Mean.	Precipitation.	Snow.
1897.				*Inches.*	*Inches.*	1898.				*Inches.*	*Inches.*
July	95	49	77.75	1.85	....	January	70	14	39.47	3.44	....
August	96.5	49	74.28	.74	....	February	68	6	41.23	.47	.31
September	96.5	34	73.10	....	....	March	76	16	47.90	7.46	1
October	91	28	63.71	.60	....	April	84	23	54.60	2.97	....
November	75	14	48.55	1.78	....	May	88	38	67.10	10.43	....
December	70	12	34.66	2.71	3	June	91	59	75.70	4.73	....

During the summer many needed repairs and improvements were made in the hatchery and annex, including the construction of lockers in the carpenter shop for the storage of tools and as receptacles for fish food. It was found necessary to reline many of the ponds, nothing having been done to them since they were constructed in 1889. The material used was 1½-inch matched pine dipped in boiling tar. New standpipes of the same material were constructed where needed, an additional 6-inch supply pipe was laid from the spring to the hatchery, and a pool 5 feet by 40 feet was built at the head of pond 5. Two new plank pools were also built—one at the head of No. 5 for storage and the other between Nos. 15 and 16—and a small egg-shaped pond was constructed at the head of No. 16.

San Marcos Station, Texas (J. L. Leary, Superintendent).

In July the employees of the station resumed the distribution of fish to applicants in the State, and disposed of 14,500 black bass and 3,700 rock bass. The distribution was again taken up April 25, 1898, and continued until June 3, during which period 17,100 black bass were handled, making a total distribution during the year of 31,600 black bass, 3,700 rock bass, and 50 crappie.

In making these plants the employees traveled 15,549 miles, 11,549 of which were free. The distribution was very successfully accomplished, but few fish being lost.

During the winter collections were made from the San Marcos and Blanco rivers to increase the stock of brood-fish. The bass commenced nesting on February 10 and were still spawning at the close of the fiscal year. Most of the eggs were deposited on clay bottom, though a few of the fish used the piles of gravel which had been placed in the pond. The fry commenced to hatch in February, and by April many were 2½ inches long. Their food was similar to that used during the past year, consisting largely of young mud shad, minnows, salted fish roe, and such natural food as the ponds contained.

The crappie and rock bass commenced nesting during the latter part of March and many of them had not finished spawning at the close of the year. Young rock bass about an inch in length appeared in large numbers in the ponds, but no crappie have been seen. Once or twice

during the season the crappie seemed to suffer from an affection of the eyes. This was attributed to the clear, shallow water, and was partly overcome by partitioning off a part of the pond and placing in this space a lot of carp, which stirred up the mud and kept the water cloudy.

In order to increase the food supply at the station a pond, 1½ acres in area, was constructed during the summer, so arranged as to have a very large area of shallow water; it was nearly oval in shape, and varied in depth from nothing to 9 feet at the stand-pipe. It was supplied with water by means of a hydraulic ram placed at the lower end of the grounds near the river and operated by the overflow of the upper ponds, the fall being 3¾ feet. By this means an average of 50,000 gallons of water per day enters the pond, and so far it has been kept full constantly, though the weather was very dry for six months of the time and the evaporation and absorption great. The ram has been running steadily since October 7, and has required very little attention except to keep the screen clean. This pond has proved a great success, both for the production of food and for rearing bass. The large area of shallow water provides a great quantity of insect life and a safe retreat for young fish. When sudden changes of temperature occur, the fish seek the deep water.

The construction of four additional ponds was commenced during the spring near the southwest end of the grounds; each of them will be ¼ acre in area and similar in character to the one built during the previous summer. A water-wheel was also built on the river to supply water to this new system. The water will be pumped into a distributing reservoir and conducted from there to the ponds by gravity. The grounds have been improved by planting Bermuda grass and shade trees, and a small orchard of pear, apple, plum, and other fruit trees was set out in the fall. These are doing well, only four having died during the year.

At the close of the year the stock on hand was as follows:

Species.	Calendar year in which hatched.			
	1897.	1896.	1894.	1893.
Black bass	9,000	50	67	99
Rock bass			200	
Crappie	52		100	100
Mud shad			200	

LEADVILLE STATION, COLORADO (E. A. TULIAN, SUPERINTENDENT).

The usual arrangements were made with the owners of Wellington, Decker, Oneva, and Musgrove lakes, and Gale, Smith, and Ridgway ponds for collecting brook-trout eggs, the owners to receive half of those obtained. Early in October the first eggs were secured from the stock-fish at the station, and from that time to the close of the season, or until work was stopped by ice, operations were actively pushed at all the points mentioned.

The results are shown in the following table:

Source.	Eggs collected.	Eggs lost.	Brook-trout fry hatched.
Station brood-fish	*428,000	108,920	22,080
Uneva Lake	256,780	8,830	247,950
Gale's fish	109,600	7,660	109,940
Smith's fish	262,900	10,650	252,250
Ridgway's fish	202,400	82,400	120,000
Wellington Lake	854,100	137,130	716,970
Young's fish	88,100	34,520	53,580
Decker's fish	96,900	53,140	43,760
Musgrove's fish	801,520	349,870	451,650
Total	3,100,300	793,120	2,010,180

*297,000 eggs of this lot shipped from station.

The total collection exceeded that of the previous year by nearly 1,000,000. The superintendent and foremen performed all the work of taking and fertilizing the eggs, and, except those from Musgrove and Decker lakes, they were of excellent quality, considering the conditions under which they were taken. The large loss on those from Musgrove Lake was undoubtedly due to the necessity of crowding the fish into a very small pond and holding them there for several weeks to ripen. The poorest eggs were obtained from fish that had been held a considerable time before spawning. All of the eggs were transferred to the Leadville Station to be hatched, and during the spring 581,000 of the fry were distributed in public waters and supplied to applicants in Colorado and Utah; 930,900 were turned over to the owners of the various lakes from which collections were made, and 340,000 were held for distribution in the fall. Shipments of the eyed eggs, aggregating 172,000, were made in January and February to private hatcheries in Utah, Montana, Washington, and California, and 150,000 were transferred to other stations of the Commission. The capacity of the hatchery was severely tested by the large collections, and in April it was found necessary to erect a number of temporary troughs. The fingerlings on hand at the beginning of the year (241,465) were carried in troughs and ponds until September, with a loss of 69,365, when they were distributed in public waters in the Northwestern States.

Of the Loch Leven trout fry on hand in July, 8,000 were distributed in October, leaving 2,000 on hand January 1; these will be held for brood stock. There were also 4,170 two-year olds on hand in July, but severe losses during the summer reduced the number to 1,870 at the close of the year. The brood-fish commenced spawning October 14, and during the fall produced 53,100 eggs, which hatched with a loss of 9,720, or about 18 per cent. When the eye-spots developed 15,000 of the eggs were shipped, and at the close of the year there were 25,100 fry.

On September 1 the 21,695 fry remaining from rainbow-trout eggs hatched during the summer were distributed with little loss. In April 26,800 eggs were collected from Loveland Lake, but the majority of them were lost in incubation. This was undoubtedly because the fish were held in a small crate for some time before they were ready to

spawn; they weighed from 5 to 8 pounds, and many of them became badly bruised. Arrangements have been made to construct a large pond for this purpose in future. There are a large number of fish in the lake, and as they are apparently in good condition, there is no doubt that it will prove a good field for collecting eggs of this species.

The brood-fish at the station yielded 15,300 eggs in May, 9,000 of which were shipped in June.

No effort was made to collect eggs at Uneva, as ice remained on the lake much later than usual, and when it finally disappeared it was found that the majority of the fish had spawned.

No collections of yellow-fin trout eggs were made this season, and all of the fry on hand at the beginning of the year were planted during the fall. There were also at the station 289,600 black-spotted trout eggs and 164,680 fry. Of these, 124,900 fry and 29,500 eggs were the result of collections made at Freeman Lake. In the fall 270,000 of the 273,000 fingerlings available for distribution were planted in the waters of Colorado, Idaho, Montana, Washington, South Dakota, and Nebraska. The remainder were placed in one of the small ponds at the station, but all except 400 escaped into Rock Creek.

On account of the uncertain results attending the work at Twin Lakes during the past five or six years, and the expense connected therewith, it has been determined to discontinue operations at that point. The usual collections were made at Freeman Lake in June, 158,800 eggs being obtained. These were transferred with little loss to the Leadville Station and were in the troughs on June 30.

The stock of fish and eggs on hand at the close of the year is shown by the following table:

Species.	Calendar year in which fish were hatched.				
	1898.		1897.	1896.	1894.
	Eggs.	Fry.			
Brook trout		340,000			195
Loch Leven trout		25,100	1,700	2,300	40
Black-spotted trout	153,600		430		
Rainbow trout	4,900	3,000			
Grayling		41,500			

During the summer many repairs and improvements were made: The superintendent's cottage was painted and the 2-story frame-house occupied by the station employees was painted, shingled, and weather-boarded. The kitchen and mess-house were repainted and repapered and new floors laid; material was gotten out for the building of a log stable near the mess-house, and posts were set preparatory to fencing in a piece of land for pasture. A 6-inch galvanized-iron pipe, 140 feet long, for drawing water from the upper Evergreen Lake, was placed in position in August, and the stumps and rubbish on the seining-grounds were removed. All of the adult trout were removed from the middle lake, which was set aside as a nursery for yearling brook and rainbow trout.

BOZEMAN STATION, MONTANA (JAMES A. HENSHALL, SUPERINTENDENT).

For the purpose of increasing the water supply during the summer, a ditch 1,500 feet long, with the necessary head-gates, etc., was constructed from a point in Bridger Creek, in the canyon, to a large supply and settling pond located southwest of the hatchery at the head of the large rearing-ponds, in order that the water might be used during the summer and fall. This pond will also be supplied with water from warm springs on the opposite side of the creek, which has a regular temperature of 77° throughout the year.

The brook-trout and steelhead fry on hand at the beginning of the year were distributed in August in suitable streams and lakes throughout the State, except 3,000 brook and 10,000 steelheads reserved for brood stock.

It having been decided not to attempt the collection of eggs at Soda Butte Lake, Yellowstone Park, and Mystic Lake, which had been examined during the previous spring, arrangements were made to establish auxiliary stations for the collection of black-spotted trout and grayling eggs in the Upper Madison River, Montana, and at Henry Lake, across the Continental Divide, in Idaho. An investigation of the streams in the vicinity of Deer Lodge, in the Big Blackfoot Valley, was also made, and an abundance of trout was found.

Early in March the equipment for the auxiliary stations, consisting of 14 hatching-troughs, 600 trays, 300 screens, and 24 egg-cases, which had been constructed by the employees of the station, was sent to Monida by rail, thence by sleighs and dog-sleds to the points selected. Operations were commenced at Henry Lake under the direction of Fish-culturist Jarvis. A temporary hatchery was established in a log cabin 15 by 15 feet, equipped with 6 hatching-troughs 8 feet long, the water supply being taken from a spring pond in the vicinity with a temperature of from 42° to 50°. About 6,000 trout were collected and placed in the ponds during the early spring, but only 186,000 eggs were obtained. Of these, 11,000 were lost in incubation, 20,000 were hatched and planted in a tributary of the lake, and the balance (155,000) were transferred to Bozeman.

The spawning season opened on April 6 and continued until May 30, though the greater part of the eggs were taken between April 15 and May 15.

Operations at Horse-thief Springs were undertaken at the same time under direction of Mr. A. J. Sprague, but early in April this site was abandoned and the equipment transferred to Red Rock, Mont., 40 miles nearer Monida and 20 miles west of Henry Lake. These stations are on opposite sides of the Continental Divide, Henry Lake being on the headwaters of the Snake River and Red Rock at the head of the Jefferson River. The equipment here consisted of 6 hatching-troughs 8 feet long, with the ordinary trays of woven wire, mesh $\frac{1}{9}$ inch by $\frac{1}{2}$ inch. The water supply was from a spring about 75 yards distant, of a temperature varying from 46° to 55°. As there was no building in the

vicinity that could be used, an awning of canvas was erected over the troughs.

The work was successful, over 3,000,000 grayling eggs being collected between May 7 and June 20. Of these, 1,500,000 were hatched at the substation and deposited in Elk Creek, an inlet of Red Rock Lake. Of the balance, 1,000,000 were transferred to Bozeman and 110,000 were shipped to other stations.

The eggs of the grayling are much smaller than those of the trout and measure one-seventh of an inch in diameter after fertilization. They are very light-colored, almost crystal-clear, and are slightly adhesive after fertilization, forming bunches and quickly developing fungus. Their specific gravity was found to be less than that of trout eggs, and from the experience gained it appears that they might be hatched or at least eyed under pressure of water, by methods similar to those employed in hatching eggs of the shad and whitefish, rather than on trays. The embryo began to show life and movement before the appearance of the eye-spot, which occurs in from 3 to 5 days. They hatch in from 10 to 12 days at a temperature of 50°. The fry are quite small, about half an inch long, and after the absorption of the yolk-sac, which requires about a week, they rise to the surface and swim freely. Considerable difficulty was experienced in providing acceptable food for them, and the loss before they commenced feeding was estimated at 50 per cent. Those hatched at the substation and planted in the creek from which the eggs were taken seemed to grow much faster than those in the hatchery.

Notwithstanding the short period of incubation, little difficulty was experienced in the transportation of eyed eggs. The consignments sent to Manchester, Leadville, and Omaha arrived in good condition. They were packed in the manner usual with trout eggs, except that no moss was placed between the trays, as the least pressure on the eggs kills the embryo. Most of the loss in shipments to Bozeman was caused by the scarcity of ice at the auxiliary station. One shipment of green eggs was made, but all of them died eventually, though they were apparently in good condition on arrival.

During the spring 100,000 brook-trout eggs and 50,000 steelhead eggs were received from the Leadville and Fort Gaston stations, and from a private hatchery at Hudson, Wis. These were hatched as usual and held at the station until the close of the year, when there remained on hand the following stock of fish:

Species.	Calendar year in which fish were hatched.	
	1898.	1897.
Grayling	500,000	....
Black-spotted trout	150,000	250
Brook trout	55,000	2,800
Steelheads	32,000	9,700

BAIRD STATION, CALIFORNIA (G. H. LAMBSON, SUPERINTENDENT).

On July 10 Mr. Livingston Stone, who had been in charge of Baird Station almost continually since its establishment, was transferred to Cape Vincent, N. Y., and Mr. G. H. Lambson was appointed superintendent. In addition to his duties at Baird the superintendent was detailed to assist Mr. J. P. Babcock, of the California Fish Commission, in the management of the Battle Creek Station, having charge of all the accounts of the latter station.

In order that the station might be in readiness for eggs from the first run of salmon, the fishing apparatus was overhauled and repaired in July, the filtering-tanks, corrals, seining-reel, and whim rebuilt, and log-cabins erected for the use of the seining crew. When fishing commenced, on August 14, a great many salmon were noticed below the rack which had been placed across the McCloud River at the beginning of the year. At the first haul 15 ripe females were captured. Fishing continued without interruption until September 20, when the first run was over. During this period 6,327 females were handled, of which 1,555 were ripe, yielding 7,000,000 eggs, an average of 4,501 per fish.

The second run commenced in October (the first haul of the seine being made on the 7th) and continued at intervals until December 8, 2,065 females being captured, of which 506 were ripe. From this run 2,194,000 eggs were collected, a total of 9,194,400 for the season.

The following table shows the daily catch of fish, ripe females, and eggs collected, with mean temperatures of water on fishing-grounds:

Date.	Fish taken.		No. of females stripped	No. of eggs taken.	Mean temperature.
	Males.	Fem.			
1897.					°
Aug. 15	520	351	21	101,120	56.0
17	532	311	20	97,600	56.0
20	425	342	28	132,800	56.0
22	518	480	59	265,600	57.0
23	329	216	24	107,200	56.5
24	543	462	50	221,680	56.0
25	410	240	36	169,600	55.4
26	390	216	30	142,000	55.0
27	651	402	61	268,400	55.0
28	663	405	62	273,000	54.3
29	306	288	35	163,000	53.6
30	337	357	62	278,000	52.7
31	369	374	76	350,000	52.7
Sept. 1	209	261	91	413,000	52.8
2	216	197	83	369,000	54.0
3	204	201	96	426,000	53.7
4	197	204	114	504,000	54.0
5	119	161	91	411,000	53.0
6	194	203	119	529,000	54.0
7	126	128	73	329,000	53.6
8	99	112	66	291,000	52.6
9	68	47	28	126,000	51.6
10	73	62	38	168,000	51.3
11	57	66	40	184,000	51.0
12	40	44	26	120,000	51.6
13	38	57	34	152,000	51.6
14	33	52	31	135,000	52.0
15	17	39	27	124,000	52.2
16	12	27	19	84,000	52.3
18	7	16	12	53,000	53.2
20	4	6	3	12,000	52.6
Oct. 8	62	40	1	3,000	51.7
15	83	48	1	2,000	47.7
20	67	45	1	5,000	47.3
21	54	67	2	5,000	47.3
22	70	44	1	4,000	46.3
23	142	78	4	18,000	46.7
24	77	46	2	7,600	45.7
26	79	42	1	3,000	46.0

Date.	Fish taken.		No. of females stripped	No. of eggs taken.	Mean temperature.
	Males.	Fem.			
1897.					°
Oct. 28	67	49	1	2,000	46.7
29	59	60	3	14,000	45.7
30	53	32	1	3,000	45.7
31	71	43	4	15,600	46.3
Nov. 2	63	25	2	6,400	46.0
3	80	67	16	65,600	45.0
4	51	39	4	17,000	45.0
5	19	22	4	15,000	45.0
6	40	28	4	16,000	43.7
7	76	41	3	14,400	43.3
8	21	15	2	7,500	42.7
9	29	18	2	9,000	42.7
10	22	27	3	14,000	44.7
11	64	41	6	27,600	46.3
12	153	89	36	155,600	45.7
13	59	48	10	45,000	45.0
14	25	16	2	8,000	43.7
15	27	19	3	11,200	41.3
17	43	27	5	19,600	42.0
18	28	33	6	25,000	43.3
19	80	116	80	359,000	43.2
20	131	120	39	177,800	43.5
21	195	217	51	222,000	45.5
22	41	27	16	70,400	44.7
23	36	30	12	54,400	43.3
24	54	67	22	96,800	44.3
25	14	8	5	24,500	43.7
29	32	22	6	25,000	43.0
30	41	39	8	34,000	44.7
Dec. 1	93	91	37	160,000	44.7
2	38	33	6	24,000	41.7
3	11	8	2	6,000	40.7
4	24	15	3	10,400	40.7
6	21	16	8	33,000	43.0
7	99	95	76	325,000	44.0
8	15	12	5	23,000	43.7
Total.	10,315	8,392	2,061	9,194,400	

Of the eggs collected at Baird, 6,255,000 were transferred to the California State Fish Commission hatchery at Sisson, Cal., 250,000 were shipped to France, Germany, Italy, and Japan, and 20,000 were sent to the Tennessee Centennial Exposition at Nashville, Tenn. The remaining eggs, together with 4,247,000 transferred from Battle Creek, were hatched and planted in McCloud River with a loss of 354,600 during incubation.

The eggs and milt were taken simultaneously in a dry pan and at once stirred with a feather until the milt was completely mixed with the eggs, when a small quantity of water was added and the eggs again stirred, after which the pan was filled with water and allowed to stand until the eggs separated. As soon as they were washed they were carried to the hatchery and placed in baskets, 30,000 to the basket. The dead ones were kept picked off until the critical stage arrived—that is, the time of the formation of the spinal column, which requires from 4 to 8 days, according to the temperature of the water. During this period the covers were kept on the troughs, and the eggs were not touched until the young fish could be plainly seen, after which the picking was continued until they were either shipped or hatched. When the covers are first removed from the troughs the eggs are very dirty, being covered ¼ inch deep with sediment and some little fungus. The loss is small, however, as the under part of the egg, kept clean by the action of the water, is plentifully supplied with air. Some fungus appears in all baskets at this station, though the losses from this source are never large. The picking of the eggs is done by Indian women, some of whom become very expert. In packing eggs for local and foreign shipments the same method was followed as heretofore.

In December a heavy rain set in, which lasted several days, and the river became so high that the racks and wheels had to be removed, which left the station dependent for its supply of water upon the ditch conveying water from Wiley Creek. At the end of two weeks this supply failed and it became necessary to resort to the steam pump for water for the hatchery.

As the number of fish hatched at this station was larger than ever before, it became necessary, owing to lack of trough-room, to plant a majority of the fry before the sac was sufficiently absorbed to permit of their swimming freely in the water. Those planted immediately after hatching collected in large banks or schools in the shallow water away from the swift currents, making no effort to hide or burrow under the stones, and were observed always heading upstream. It is feared that large numbers of them were destroyed by fish; one trout captured at the time was found to have 43 young salmon in its stomach. Those liberated with the sac nearly absorbed disappeared at once under the gravel and stones and remained there until the sac was completely absorbed, when they were observed to go out in search of food in small schools. They then gradually worked their way out into deeper and swifter water until they disappeared. Half a million were held in the

troughs until they were ready to take food, when they were liberated and immediately sought deep and swift water. Six months later numbers were caught with the fly, like trout. In June, 1898, young salmon of two sizes appeared in the river in large numbers, one about 1½ inches long and the other from 3 to 4 inches. The first were supposed to be the result of the last plants and the larger ones of the plant of 1896, though this is only surmise.

In hauling the seine for salmon many large rainbow trout were taken, one weighing 10 pounds and a number from 5 to 7 pounds. These were all returned to the water. Several Dolly Varden trout were also captured. A number of Von Behr trout, the result of a plant of 1,500 of this species in the Upper McCloud River from the Sisson hatchery, were caught with a fly and returned to the water.

During the spring an orchard, covering about 2½ acres, and consisting of apples, pears, peaches, etc., was set out and repairs made to the foreman's cottage and the building occupied as post-office.

The following table gives the maximum, minimum, and mean temperatures of air and water at the station for the fiscal year:

Month.	Maximum.		Minimum.		Mean.		Month.	Maximum.		Minimum.		Mean.	
	Air.	Water.	Air.	Water.	Air.	Water.		Air.	Water.	Air.	Water.	Air.	Water.
1897.							1898.						
July	97	59	73	56	85	57.5	January	56	43	35	38	45.5	40.5
August	100	58	72	54	86	56	February	60	53	39	40	49.5	46.5
September	97	56	59	50	78	53	March	69	59	43	45	56	52
October	84	53	46	46	65	49.5	April	86	56	49	48	67.5	52
November	70	47	42	41	56	44	May	90	56	52	48	71	52
December	65	45	41	39	53	42	June	92	61	60	50	76	55.5

Battle Creek Station, California (J. P. Babcock in charge).

During the summer the ditch used for conducting water from Battle Creek to the hatchery was repaired, the buildings put in order, and a contract made for the erection of a substantial retaining-rack in Battle Creek on the site of the old temporary one operated in the past. This work was much delayed, and, fearing that the first run of fish would pass up the creek before the rack could be completed, a small weir was placed at a riffle half a mile below, the material of the old 1896 rack being used in its construction. This weir proved of great value and remained in place throughout the season, as there were no heavy rains to raise the creek. Trap weirs were also placed at the mouth of Battle Creek to prevent salmon which entered it from returning to the Sacramento River. The failure to provide for this in past years tended to reduce the catch of fish very materially. The seining-grounds below the riffle rack were cleared of snags and brush and the live-boxes placed in the deep water below the weir.

The force engaged was about the same as that employed the year before, consisting principally of residents in the vicinity. Mr. W. H. Shebley had charge of the spawning and seining crews and Mr. E. W. Hunt directed the work in the hatchery.

Seining commenced October 20 and two crews were kept busy night

and day from November 7 until the middle of December, at which time there were still a few fish left in the creek. Only the ripe females and such males as were necessary to accomplish fertilization were transferred from the seines to the crates, the green fish being returned to the creek. No record was kept of the ripe males used, as they were always in excess of the demand. The females were thrown on the banks to die after the eggs had been expressed from them, but the males were returned to the live-boxes and manipulated each day until exhausted. Such of the dead fish as were fit for food were given to those applying for them, and over 600 wagons received fish during the season, some of them coming from points 100 miles away.

The first eggs were secured October 22, the collections to the close of the season being 48,527,500. The smallest take in one day was 85,000, the largest 2,220,000; the average was 1,250,000 per day. The total number of fish spawned was 8,764. The total loss of eggs in the hatchery was 3,395,000. The salmon handled weighed from 2½ to 40 pounds, but the average weight was about 22 pounds.

The following table shows the daily catch of ripe females, eggs collected, daily loss in the hatchery, and temperature of water:

Date.	Number of fish taken.		Number spawned.	Number of eggs taken.	Daily loss of eggs in hatchery.	Water temp. in hatchery, a. m.	Water temp. in hatchery, p. m.	Date.	Number of fish taken.		Number spawned.	Number of eggs taken.	Daily loss of eggs in hatchery.	Water temp. in hatchery, a. m.	Water temp. in hatchery, p. m.
	6 a. m. to 6 p. m.	6 p. m. to 6 a. m.				°	°		6 a. m. to 6 p. m.	6 p. m. to 6 a. m.				°	°
Oct. 20	23	....	....	....	....	....	....	Nov. 30	136	96	150	880, 000	50, 000	50	53
21	186	....	....	....	....	....	....	Dec. 1	85	55	228	1, 360, 000	52, 500	51	52
22	60	....	81	455, 000	....	56	55	2	41	36	143	800, 000	57, 500	46	50
23	29	....	96	560, 000	12, 500	53	54	3	26	20	78	400, 000	55, 000	44	48
24	86	....	124	805, 000	17, 500	52	56	4	44	....	45	240, 000	62, 500	44	48
25	71	....	89	560, 000	17, 500	52	56	5	....	74	....	....	67, 500	48	49
26	157	....	157	910, 000	15, 000	52	58	6	90	30	118	720, 000	62, 500	50	52
27	193	....	65	385, 000	25, 000	52	58	7	58	....	127	760, 000	55, 000	50	51
28	298	....	191	1, 050, 000	20, 000	53	58	8	40	28	58	360, 000	65, 000	50	51
29	239	....	300	1, 680, 000	40, 000	54	58	9	5	....	67	360, 000	62, 500	48	49
30	252	....	239	1, 400, 000	37, 500	54	58	10	....	....	17	85, 000	57, 500	50	51
31	170	....	252	1, 435, 000	47, 500	53	58	11	....	....	....	....	67, 500	51	51
Nov. 1	266	....	170	945, 000	30, 000	54	58	12	....	....	....	....	50, 000	50	52
2	174	....	256	1, 520, 000	40, 000	54	56	13	41	....	....	....	62, 500	49	50
3	198	....	182	1, 040, 000	37, 500	52	56	14	....	....	41	247, 500	70, 000	48	50
4	170	....	200	1, 120, 000	27, 500	51	54	15	....	....	....	....	55, 000	47	48
5	176	....	170	920, 000	35, 000	50	54	16	....	....	....	....	65, 000	45	48
6	159	....	175	1, 000, 000	35, 000	50	52	17	....	....	....	....	70, 000	44	47
7	97	95	160	880, 000	37, 500	48	51	18	....	....	....	....	52, 500	45	47
8	106	106	191	1, 000, 000	27, 500	47	50	19	....	....	....	....	65, 000	43	46
9	110	139	212	1, 120, 000	32, 500	48	53	20	....	....	....	....	60, 000	43	46
10	197	99	247	1, 280, 000	27, 500	50	55	21	....	....	....	....	65, 000	43	46
11	259	138	295	1, 487, 500	37, 500	53	56	22	....	....	....	....	60, 000	43	46
12	143	162	397	2, 137, 500	62, 500	52	56	23	....	....	....	....	62, 500	44	46
13	214	225	297	1, 560, 000	52, 500	52	53	24	....	....	....	....	65, 000	45	48
14	67	170	439	2, 220, 000	52, 500	50	53	25	....	....	....	....	25, 000	46	49
15	107	140	242	1, 170, 000	47, 500	46	50	26	....	....	....	....	15, 000	48	52
16	64	154	250	1, 290, 000	37, 500	48	51	27	....	....	....	....	20, 000	49	51
17	72	167	215	1, 142, 000	67, 500	48	50	28	....	....	....	....	15, 000	48	50
18	127	110	242	1, 317, 500	37, 500	50	54	29	....	....	....	....	17, 500	46	48
19	67	104	234	1, 275, 000	62, 500	50	54	30	....	....	....	....	12, 500	48	51
20	24	194	170	892, 500	82, 500	53	54	31	....	....	....	....	7, 500	46	50
21	64	93	213	1, 190, 000	70, 000	50	52	Jan. 1	....	....	....	....	12, 500	46	50
22	116	106	162	935, 000	72, 500	50	50	2	....	....	....	....	17, 500	47	50
23	33	172	221	1, 232, 500	70, 000	50	52	3	....	....	....	....	7, 500	47	50
24	105	69	207	1, 120, 000	62, 500	49	51	4	....	....	....	....	5, 000	47	51
25	33	40	170	1, 040, 000	65, 000	46	49	5	....	....	....	....	10, 000	48	50
26	65	36	78	400, 000	57, 500	45	49	6	....	....	....	....	15, 000	50	51
27	55	47	102	560, 000	52, 500	46	49	7	....	....	....	....	12, 500	46	48
28	50	71	100	600, 000	67, 500	46	49								
29	71	78	121	680, 000	65, 000	48	50	Total.	5,719	3,065	8, 784	48,527,000	3,395,000	....	....

As soon as the eggs had been fertilized they were hauled in wagons from the fishing-grounds to the hatchery (about two-thirds of a mile), where they were placed in baskets until eyed and ready for shipment. The first consignment was forwarded to Sisson on November 16, and shipments continued from that time until January. Of the total number collected 24,000,000 were turned over to the California Commission, to be hatched on the Sacramento and Eel rivers; 4,000,000 were sent to Baird; 6,000,000 were sent east on car No. 3; 2,000,000 were transferred to Bear Valley Station and 3,000,000 to Clackamas, Oreg.

The remaining 6,000,000 yielded 5,885,500 fry, which were liberated in Battle Creek between December 16 and February 28, on which date the station was closed and placed in charge of a watchman. The total loss of eggs during incubation was 3,395,000.

In December Mr. Cloudsley Rutter was detached from Battle Creek and ordered to Olema, Bear Valley, Cal., to hatch and liberate the 2,000,000 eggs transferred to that point. The loss during incubation was small, 1,970,000 fry being hatched, but owing to limited facilities for holding them in the hatchery it was found necessary to liberate them a few days after the bursting of the shell, in Olema Creek, Papermill Creek, Hatchery Pond, Hatchery Creek, and a brook near Inverness.

In depositing the fry, shoals or riffles were selected as the most suitable places. When the fry were first planted the creeks were very low, which enabled Mr. Rutter and his assistant to observe their movements closely. During the first nine days they moved neither up nor down stream, but collected in groups in shallow places. At one spot from 4,000 to 5,000 were found in an eddy behind a rock. After the heavy rain of February 1, however, no further traces of them could be seen. On February 26 the station was closed and observations were discontinued, owing to lack of funds. The grounds upon which the plants had been made were examined again on April 10 and very few fry were found in the creek, though enough had been planted to give 2 to every square foot of surface from the mouth to the highest point at which deposits were made.

FORT GASTON STATION, CALIFORNIA (W. E. DOUGHERTY IN CHARGE).

Owing to lack of rains during the summer and fall, very few salmon and no steelheads reached the traps in the spring; consequently no work was done at Fort Gaston. At Redwood large numbers of salmon were taken below the rack, but owing to lack of facilities only about half of them were used. During the year 1,410,000 steelhead eggs, 1,283,450 eggs of the chinook and nerka salmon, and 41,000 rainbow-trout eggs were collected; 710,000 steelhead eggs were shipped to eastern stations; the balance were hatched, and the fry resulting from the steelheads and the salmon were liberated in Redwood Creek. The rainbow-trout fry (35,950) were deposited in Mill, Pine, and Fish Tangatang creeks.

As these stations are practically inaccessible, it being necessary to pack on mules all material carried in and out, and as better results can

be secured more economically at other points, they were abandoned at the close of the year.

CLACKAMAS STATION, OREGON (W. F. HUBBARD, SUPERINTENDENT).

Arrangements were made to operate (in connection with Clackamas Station) substations on the Salmon and Little White Salmon rivers; also a hatchery belonging to the Columbia River Packers' Propagating Company on the headwaters of Clackamas River; and with Mr. R. D. Hume on Rogue River.

The rack across the Clackamas was finished early in July. Heretofore it had been constructed on a shallow riffle a short distance above the station, but this season the property-owners controlling the shores objected, and it became necessary to locate it directly opposite the station in much deeper water. During the summer the hatchery was overhauled and placed in thorough repair, new foundations, sills, and flooring being laid; many old troughs, which had been used since the establishment of the station, were replaced by new ones. The hatchery was further improved by putting in new skylights. The water supply, which had been very unsatisfactory in the past, was increased.

Early in September, all repairs and preparatory work having been completed, operations were commenced, but no ripe fish were taken until September 15. The fishing below the rack was continued every night, but very few fish were taken and only 386,650 eggs were collected in September. As the prospects for large collections in the vicinity of the station were poor, arrangements were made early in October, with Mr. G. H. Oldenburg, for collecting eggs at a point about 4 miles below the station, at the rate of 40 cents per 1,000, eyed; and 824,800 were secured from this source between October 20 and December 3, the eggs being delivered in good condition.

Fishing operations continued until October 24, when the water in the river rose so high that the men were compelled to stop work. They resumed on November 7, but by this time all the salmon in the vicinity of the rack had spawned. As a result of the season's work, 1,672,275 eggs were taken from the Clackamas River.

During September 1,066,600 eggs were received from Salmon River, and commenced hatching on the 16th. The fry from the first lot were not as strong as usual, which was attributed to the fact that the water at Clackamas Station, taken from Clear Creek, is between 10° and 15° warmer than that of Salmon River. As soon as the temperature fell there was no difference between the fry hatched from eggs collected on the Salmon and those on the Clackamas. Between October 19th and November 16th, 4,000,000 eggs were transferred from the Little White Salmon in four shipments, and on January 18 another consignment of 3,000,000 arrived from Battle Creek. These were in excellent condition, only 2,200 being lost in transit. Plants of fry were made from time to time, commencing October 7, in Clackamas River and Clear Creek, the last plant being made on April 28. As a result of the eggs collected at

the various substations and transferred to Clackamas, 10,029,796 fry and fingerling fish were liberated in tributaries of Clackamas River.

A noteworthy experiment was tried during the season with one basket of eggs. A lot of 20,000, collected October 30, were placed in a basket, and on the following day 208 dead ones were taken off. The basket was then covered so as to exclude light, and left undisturbed until the twenty-first day, when the eggs were picked over again and 365 dead ones removed. During the undisturbed period the top layer became covered with sediment so thick that the eggs were not visible beneath, but the lower side, owing to the current of water through the basket, was perfectly clean. A larger percentage than usual of these eggs hatched, and the fry were apparently good. This method, if it proves practicable on a large scale, will effect not only an economy of time and labor, but probably the saving of many eggs, as these are often killed by picking over during the critical stage, between the ages of 9 and 15 days. In November, owing to the overcrowded condition of the hatchery, it became necessary to provide additional room for the fry, which were hatching rapidly. Fifty new troughs, 24 feet long, were constructed and placed out of doors near the flume leading from the spring. This afforded ample room for holding the fry until they had arrived at the proper stage for planting. Two hundred thousand fry were held until April, and when liberated in Clear Creek they were between 2 and 3 inches in length.

In December 10,000 Loch Leven trout eggs were received from Northville, Mich., for the Oregon Fish Commission. These were hatched and planted at the request of Hon. H. D. McGuire during the months of March and April in Sucker Lake, Crystal Lake, and Clackamas River.

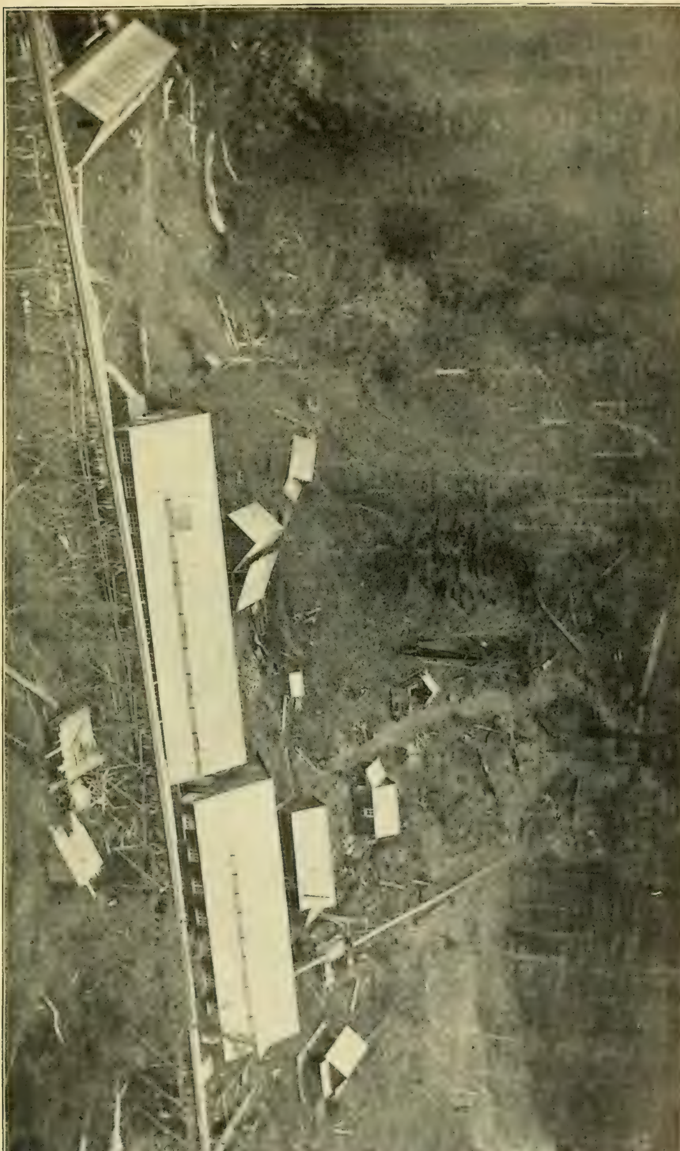
Upper Clackamas.

This hatchery was built in the spring of 1895 by the Columbia River Packers' Propagating Company of Oregon, at the headwaters of the Clackamas River, in the Cascade Mountains, about 50 miles from Clackamas, and operated by them for two years. At the suggestion of Hon. H. D. McGuire, fish commissioner of the State, it was turned over to the United States Fish Commission with the understanding that it would be operated to its full capacity during the fall. The hatchery is very inaccessible, and all supplies needed for the work have to be carried in on the backs of mules or men, as wagons can be used only over the first 20 miles, the last 30 being only a rough mountain trail. A trip to the station is difficult, requiring from two to three days, and as the country is entirely uninhabited it is necessary to camp en route. But the site is especially valuable from the fact that it is the spawning-ground of the earliest run of chinook salmon in the Clackamas River, and, except Salmon River, is the only place in the Columbia River Basin where eggs from this run can be secured as early as July. The station was first visited by the superintendent on June 16, and arrangements made to commence work under direction

of Mr. King Spurgeon. The property at the station consists of two sheds, 20 by 80 feet, which are used as hatcheries. These are cheap structures set upon posts, without sides or floors. There is also a log cabin 15 by 16 feet and a shanty 16 by 24 feet, made of cedar bark, for the accommodation of the men and storage of the necessary equipment for operating the station. The water supply is taken by gravity from a small spring brook.

In order to stop the ascent of the salmon, a contract was made at once to build a rack across the river. This was finished late in June, and another rack was constructed over Oak Grove Creek, a large tributary flowing into the Clackamas River below the station, where many salmon ascend to spawn. The fish commenced collecting below the racks before their completion, indicating that some had already passed up. On July 1 a crew of men was employed, the station was put in order, the troughs and baskets repaired and asphalted, the seining-grounds cleared, and a bridge built over Oak Grove Creek. The first collections were made on July 17, and operations continued daily from that time to the end of the season, the fish being caught with a seine hauled just below the rack. It was found necessary to build a second rack a short distance below the first, to prevent the fish from going down the river while fishing operations were in progress. This lower rack was constructed with a trap in the center, so that the fish might pass up, but could not return.

As the season advanced and the egg collections increased it became apparent that the water supply from the small brook would not be sufficient, and, as there was no way of increasing it, troughs were placed on a gravel bar near a riffle in the river, where there was fall enough to supply them with water from the river above; 12 hatching-troughs, 16 feet long, were placed on this riffle, and a rough shed was constructed over them. These troughs gave very good results, though they were in danger of being carried away by a sudden rise in the river; but this, fortunately, did not occur until the eggs had been removed. It also became necessary to rearrange the troughs in the sheds so that the water could be used over and over again, care being taken to aerate it as thoroughly as possible, and although the results were satisfactory, it is strongly urged that a better supply be secured for the next season. Between July 17 and August 26, there were taken and placed in the hatching-troughs 5,045,000 eggs. Those collected in July commenced hatching about the middle of August, and owing to the crowded condition of the troughs it became necessary to plant many of them a few days after hatching. The last fry hatched on October 15, the average period of incubation being from 34 to 35 days for the earlier lots and 50 days for the last. As soon as trough room permitted, the fry were held until the yolk-sac was nearly absorbed, when they were deposited on the spawning-grounds in Clackamas River. The station was closed when the last plant of fry was made on December 14, the property stored, and buildings left in charge of a watchman.



LITTLE WHITE SALMON RIVER LOOKING NORTH, SHOWING THE TWO NEW HATCHERIES, OFFICE, AND MESS-HOUSE.

SALMON RIVER.

Early in the spring of 1897 arrangements were made with Mr. Thomas Brown for collecting quinnat-salmon eggs on the Salmon River on the same terms as heretofore, viz: 40 cents per 1,000 for eyed eggs, the construction of the rack, capture of the fish and care of the eggs until they reached that stage to be undertaken by him, and the Commission to furnish the necessary troughs and other hatching apparatus. The rack was placed across the Salmon River in May, at the same point where operations had been conducted the previous season, and another rack was built across the Sandy River later in the season for the purpose of turning the salmon from that stream into the Salmon River. At the beginning of the year, when the racks were completed, numbers of fish appeared below them, and indications pointed to a large collection of eggs; but many fish were captured before the spawning season by fishermen and others living in the vicinity, which materially reduced the available supply.

The first eggs were taken on July 22 and the last during the latter part of August. During this period 1,216,600 eggs were secured from the 389 females; of these, 1,066,600 were shipped to Clackamas in four consignments during September, and the balance were hatched and liberated in the river near the rack.

ROGUE RIVER.

During the early spring an investigation of various sites on the Rogue River was made by the superintendent, with a view to establishing an auxiliary station for collecting quinnat-salmon eggs. A number of sites were examined in the vicinity of Gold Hill, and a point was selected about 12 miles above that place, the water to be secured from an irrigation ditch connected with Rogue River; but before the arrangements could be completed with the parties owning the land, who lived at Jacksonville, Oreg., Mr. R. D. Hume, of Wedderburn, Oreg., agreed to erect a hatchery on Rogue River and equip it, provided the United States Fish Commission would operate it. This offer was accepted and the site near Gold Hill abandoned. The point selected by Mr. Hume is at the mouth of Elk Creek, about 26 miles from Central Point. Arrangements were made with J. J. Pankey to build a rack across the river, capture the fish, and furnish eyed eggs to the Commission at the rate of 40 cents per 1,000. In August a hatching-house, 24 by 50 feet, was built on the banks of the river above, equipped with 8 hatching-troughs, 35 feet long, 12 inches wide, and 10 inches deep, and with a filtering-tank 12 feet long, 4 feet wide, and 3 feet deep in one end. The water supply was taken from Elk Creek, its temperature being from 12° to 14° warmer than that of Rogue River. In order to raise the water in the creek to a sufficient height, a dam 10 feet high and 100 feet long was built about 1,800 feet from the hatchery, the water being conveyed in a 2-foot flume.

In September Mr. G. H. Tolbert, fish-culturist, was detached from Fort Gaston Station and placed in charge of the work. The building

was completed shortly afterwards, and the presence of many salmon below the rack afforded a fair prospect for good collections. A few eggs were taken in September, but the bulk was collected in October. During October and November 2,027,000 eyed eggs were delivered by Mr. Pankey. The results were not satisfactory, as it is believed that there was a sufficient number of salmon in the river to have yielded at least 5,000,000 more if the fishing had been properly managed. One of the principal objections to this site is that there is no deep water below the rack in which fish can collect, and as soon as they become frightened by the seining operations they descend the river for several miles. The hatchery was not large enough to accommodate the number of eggs taken, and it became necessary to provide additional troughs outside the building. Quite a heavy loss occurred during incubation; the shells of the eggs appeared to be so tough that the fry could not burst through. It was noticed that those obtained from the Rogue River salmon were much larger than those collected on the tributaries of the Clackamas, three of them laid side by side measuring $1\frac{1}{8}$ inches.

A great deal of rain fell during November, raising the water in Elk Creek and carrying away about 30 feet of the top of the dam; fortunately no damage resulted. On December 8 Mr. Tolbert was relieved and Mr. J. W. Berrian put in charge. As the weather became colder, ice and slush formed in the flume to such an extent that it was decided to liberate all of the fry and not run the risk of losing them in the troughs. The last plant was made on February 10, when the station was closed and left in charge of a watchman. The total number liberated was 1,910,045; they were deposited on the spawning-grounds in Rogue River, near Trail, Oregon.

Little White Salmon.

As the results secured the previous year indicated that large numbers of eggs could be obtained on the Little White Salmon River, arrangements were made to operate at that point on an extended scale. Mr. S. W. Downing, foreman of Alpena Station, was detailed to assist the superintendent, and reported for duty on July 20. The old hatchery, which had been floated from its foundations the previous winter by the rising of the Columbia River, was repaired and the hatching-troughs made ready for the reception of eggs. The mess-house was rebuilt and enlarged, and a rack was placed across the river. A new hatchery was also commenced and completed during the month of August. This building is a substantial structure of wood, 42 feet by 80 feet, and is so arranged that the roof is supported by the sides of the building, thereby leaving the entire floor space free of posts and giving more room for hatching operations. The floor is terraced uniformly from one end of the building in four sections, with a difference of 8 inches in elevation from one section to the next. On each of these a row of troughs runs lengthwise of the building, the troughs in each maintaining an elevation of 8 inches above those in the next, in conformity with the plan of the floor. They are fed with water conducted by a flume to

a supply-trough placed against the end wall. By this arrangement all of the troughs are at a uniform height from the floor, and the manipulation of eggs is much easier than where troughs of different heights are set upon a level. The building is lighted by skylights in the roof and by windows in the sides and ends.

Very few fish were seen during August, but in September they began to make their way up the river in considerable numbers. The first spawning salmon were noticed on September 12, when fishing was regularly undertaken. Within three days afterwards over 1,000,000 eggs had been collected. Various methods were employed in catching the fish, some being taken with traps and others with seines. One trap was built in the upper side of the rack, but very few fish were captured in it. The seining was done in a pool below the rack and at various points along the lagoon. The greater number of fish, however, were caught in traps built on the riffles some distance below the rack, into which the fish were driven by hauling a seine downstream and forcing them into the trap. As soon as the spawning season commenced a large force was employed and work continued night and day. By September 28 all of the hatching-baskets at the station were filled with eggs, 11,286,000 having been collected; and as there were many spawning salmon still in the river, it became necessary to provide additional apparatus. Hatching-baskets were transferred from Clackamas Station, and work was resumed on October 2; by the 6th these baskets had also been filled, bringing the collections up to 12,649,000. The actual number of days on which eggs were taken was 22, making the daily average 575,000. The greatest number taken on one day was on September 22, when 1,155,000 were collected.

In order to simplify the handling of large females, they were knocked on the head with a club before any effort was made to strip them. This blow stunned the fish, and it was possible to express the eggs without any struggling or muscular contractions on the part of the fish, thereby saving much time and labor. The eggs were fertilized in the usual way, four men being detailed to take the fish from the corrals, strip them, impregnate, wash, and transfer the eggs to the hatchery. As a rule, the eggs were allowed to remain in the pan about an hour before being washed, but with the last million obtained this period was reduced to a few minutes. These eggs were transferred to the hatchery, and proved to be better than any of the earlier collections.

The spawning season here lasts only a month, but during that period the river is alive with fish, and it is believed that former collections could be largely exceeded, as at no time was it necessary for the men to fish more than a few hours a day. Fortunately the weather during the hatching season was pleasant; otherwise the fish in the troughs on the outside would have undoubtedly been killed by ice. Several severe snowstorms occurred, but no damage was done.

On October 18 Mr. Downing was detached from the station, and Mr. J. A. Tolbert was placed in charge as foreman. As soon as the spawn-

ing season was completed additional troughs were constructed and placed out of doors for the accommodation of the fry. The eggs commenced hatching in November, and the first plant of fry was made on December 18. Plants continued from this time until January 29, when the last were liberated in Little White Salmon River, which is one of the best natural spawning-grounds of the quinnat salmon. The total number of fry planted was 7,391,000. After all had been disposed of the station was closed, and the watchman was employed for the balance of the year in constructing a road from the station to the county road.

Siuslaw River Station, Oregon (L. E. Bean in charge).

At the urgent request of the Representatives of the State of Oregon, and with the understanding that the canners and fishermen on Siuslaw River would cooperate with the U. S. Fish Commission, arrangements were again made to open the hatchery near Mapleton, Oreg., the owner having tendered its use free of cost.

In August Mr. L. E. Bean was placed in charge, and arrangements were made for collecting salmon down the river and transferring them in live-boxes to the hatchery, to be held until ready to spawn. A rack was placed across the north fork and another on the main river, 1½ miles above the station, at the head of tide water. Crates were also constructed for transferring the fish; they were 18 feet long, 9 feet wide, and 6 feet deep, and so made as to exclude light, sufficient space being left between the planks below the surface of the water to admit of the free circulation of water.

A collection of 100 salmon obtained from the seine of Capt. William Kyle were transferred to the boxes, but half of them were lost immediately after being placed in the live-boxes, and the balance died in transit, though the utmost care was exercised in handling them. This method was then abandoned and collections were made by means of gill nets and a trap fished below the rack, the trap being made of two old seines. A few fish were caught in this way while the water was muddy, but as soon as it became clear they avoided the traps. The majority were taken in gill nets set in the evening and fished from time to time during the night in the deep holes below the rack. Two nets were used, one of which was 30 fathoms long, 7-inch mesh, and the other 20 fathoms long, 9-inch mesh. On the night of October 21, 63 chinooks were taken in the two nets. The majority of those taken in the 9-inch mesh were injured and died in a short time; the others were held until the close of the season with comparatively small loss.

At the close of operations there were 117 ripe females and 97 males in the live-boxes. These yielded 544,275 eggs, of which 104,000 died in incubation. They were placed in the hatchery as soon as fertilized, and hatched during the month of January. The 440,275 fry resulting from them were liberated at suitable points in Spring Creek and the Siuslaw River during the latter part of February and the first of March.

LITTLE WHITE SALMON RIVER, SHOWING HATCHERIES AND LUMBER FLUME.

DISTRIBUTION TABLES.

The following tables show the distribution of fishes by States and Territories, and the distribution in detail by species:

Résumé, by States and Territories, of the distribution and assignment of fish and eggs.

State or Territory.	Species.	Eggs.	Fry and fingerlings.	Adults and yearlings.
Alabama	Rainbow trout			1,000
Arizona	Rainbow trout			2,000
	Black bass, large-mouth			650
	Rock bass			400
	Strawberry bass			400
Arkansas	Rainbow trout			11,200
	Black bass, large-mouth			2,250
	Rock bass			1,600
	Strawberry bass			1,800
California	Quinnat salmon	30,255,000	15,643,300	
	Steelhead trout		650,000	
	Loch Leven trout	15,000		
	Rainbow trout		35,885	4,085
	Brook trout	85,000		
Colorado	Loch Leven trout			8,000
	Rainbow trout		7,000	
	Black-spotted trout		199,000	
	Brook trout		561,000	91,600
	Yellow-fin trout		7,500	
	Black bass			400
Connecticut	Shad		9,775,000	
	Atlantic salmon	100,000		
	Landlocked salmon	10,000		
	Rainbow trout	25,000		800
	Brook trout	10,000	20,000	
	Lake trout	300,000		
	Black bass, large-mouth			200
Delaware	Shad		15,479,000	
	Rainbow trout			570
	Black bass, large-mouth			400
	Crappie			100
District of Columbia	Shad	5,179,000	1,717,000	3,036,000
	Loch Leven trout		1,000	
	Lake trout		1,000	
Georgia	Rainbow trout			4,800
Idaho	Black-spotted trout		8,000	
	Brook trout			5,000
	Lake trout	10,000		
Illinois	Black bass, large-mouth			2,025
	Crappie			475
Indiana	Loch Leven trout		5,000	
	Brook trout		15,000	
	Lake trout		30,000	
	Black bass, large-mouth			4,415
	Crappie			700
Indian Territory	Rainbow trout			5,250
	Black bass, large-mouth			400
	Rock bass			680
	Strawberry bass			700
Iowa	Rainbow trout		3,900	800
	Brook trout		18,700	2,600
	Lake trout		441,000	
	Black bass, large-mouth			300
	Crappie			200
	Strawberry bass			100
Kansas	Rainbow trout			1,950
	Black bass, large-mouth			3,041
	Crappie			215
	Rock bass			2,000
Kentucky	Rainbow trout			1,600
	Black bass, large-mouth			1,535
	Crappie			550
	Rock bass			221
	Strawberry bass			242
Maine	Quinnat salmon	50,000	901,066	229,800
	Atlantic salmon		1,975,068	220,335
	Landlocked salmon	66,243		79,990
	Steelhead trout	50,000	58,907	6,172
	Rainbow trout			355
	Brook trout	25,000	356,721	
	Lake trout	75,000	55,998	
	Scotch sea trout			1,489
	Golden trout	10,000	79,144	
	Lobster		21,500,000	
Maryland	Shad	68,881,000	65,867,000	
	Rainbow trout	25,000		10,505
	Black bass, large-mouth			3,726
	Black bass, small-mouth			309
	Rock bass			200
Massachusetts	Shad		540,000	

Résumé of the distribution and assignment of fish and eggs—Continued.

State or Territory.	Species.	Eggs.	Fry and fingerlings.	Adults and yearlings.
Massachusetts	Quinnat salmon			200
	Atlantic salmon			100
	Landlocked salmon	10,000		5,548
	Steelhead trout			200
	Rainbow trout	10,000		2,680
	Brook trout		80,000	
	Lake trout	100,000		
	Scotch sea trout			100
	Black bass, large-mouth			640
	Black bass, small-mouth			30
	Codfish		202,570,000	
	Pollock		4,455,000	
	Flatfish		39,337,000	
	Lobster		71,334,000	
Michigan	Landlocked salmon	10,000		
	Steelhead trout		91,000	3,500
	Loch Leven trout		3,000	
	Rainbow trout			8,000
	Brook trout		170,000	24
	Lake trout		6,268,400	
	Whitefish		8,198,000	
	Black bass, large-mouth			1,550
Minnesota	Steelhead trout		115,000	
	Brook trout		66,550	
	Lake trout		1,713,000	
	Black bass, large-mouth			750
	Crappie			300
Missouri	Rainbow trout		14,000	25,205
	Black bass, large-mouth			2,635
	Crappie			25
	Rock bass			800
	Strawberry bass			1,300
Montana	Steelhead trout			43,500
	Rainbow trout		3,000	
	Black-spotted trout		24,000	
	Brook trout	2,000		15,967
	Grayling		1,500,000	
Nebraska	Rainbow trout		4,000	14,000
	Brook trout			5,000
	Black bass, large-mouth			130
	Rock bass			200
	Strawberry bass			70
New Hampshire	Atlantic salmon	100,000		
	Landlocked salmon	10,000		10,000
	Steelhead trout		30,000	
	Rainbow trout		4,300	
	Brook trout	25,000	54,975	
	Whitefish	200,000		
	Lobster		1,200,000	
New Jersey	Shad		11,110,000	
	Landlocked salmon	10,000		
	Steelhead trout		12,800	
	Rainbow trout			2,000
	Brook trout	20,300		
	Black bass, large-mouth			2,350
New Mexico	Rainbow trout			2,100
	Black bass, large-mouth			500
	Rock bass			200
	Strawberry bass			800
New York	Shad		5,800,000	
	Quinnat salmon		4,691,800	200
	Atlantic salmon	100,000	97,071	200
	Landlocked salmon	15,000		16,000
	Steelhead trout		90,060	200
	Loch Leven trout		6,282	
	Rainbow trout		19,012	500
	Brook trout		84,152	
	Lake trout	200,000	1,000,971	
	Pike perch		10,043,750	
	Black bass, large-mouth			800
North Carolina	Shad	1,811,000	6,932,000	
	Rainbow trout			11,500
	Black bass, large-mouth			600
	Crappie			100
	Rock bass			1,715
North Dakota	Black bass, large-mouth			3,010
	Crappie			160
Ohio	Loch Leven trout	5,000		
	Rainbow trout			300
	Brook trout	2,000	29,000	
	Lake trout		908,800	
	Whitefish		80,290,000	
	Pike perch		71,110,000	
	Lake herring		18,970,000	
	Black bass, large-mouth			2,236
	Black bass, small-mouth			20
	Sunfish			69

Résumé of the distribution and assignment of fish and eggs—Continued.

State or Territory.	Species.	Eggs.	Fry and fingerlings.	Adults and yearlings.
Ohio	Rock bass			910
	Strawberry bass			100
Oklahoma Territory	Rainbow trout			4,100
	Black bass, large-mouth			2,500
	Rock bass			4,800
	Strawberry bass			400
Oregon	Quinnat salmon		16,915,506	
	Loch Leven trout		5,175	
	Brook trout			6,300
Pennsylvania	Shad		8,250,000	
	Atlantic salmon	100,000		
	Landlocked salmon		3,085	
	Rainbow trout			23,000
	Brook trout		5,000	1,000
	Rock bass			2,310
Rhode Island	Landlocked salmon	5,000		1,550
	Brook trout		10,000	
	Lake trout		8,000	
	Black bass, large-mouth			1,300
	Black bass, small-mouth			460
	Lobster		1,200,000	
South Carolina	Shad		2,000,000	
	Black bass, large-mouth			500
	Crappie			250
	Rock bass			500
South Dakota	Black-spotted trout		14,400	
	Brook trout		21,000	6,500
	Lake trout		28,000	
Tennessee	Rainbow trout		225	9,631
	Black-spotted trout		3,000	
	Black bass, large-mouth			2,766
	Black bass, small-mouth			65
	Crappie			172
	Rock bass			1,436
Texas	Rainbow trout			3,975
	Black bass, large-mouth			30,405
	Crappie			50
	Rock bass			3,700
Utah	Rainbow trout		4,000	
	Brook trout	60,000	20,000	12,000
Vermont	Landlocked salmon	10,000	3,920	8,000
	Steelhead trout		60,587	
	Rainbow trout		700	2,250
	Brook trout	20,000	334,700	
	Lake trout	300,000	18,800	
	Black bass, large-mouth			450
Virginia	Shad		21,685,000	
	Rainbow trout			91,976
	Black bass, large-mouth			1,200
	Black bass, small-mouth			1,000
	Crappie			72
	Rock bass			1,350
Washington	Quinnat salmon		7,391,886	
	Black-spotted trout		5,000	
	Brook trout	25,000		11,000
West Virginia	Rainbow trout			3,400
	Black bass, large-mouth			300
	Rock bass			300
Wisconsin	Landlocked salmon	10,000		
	Steelhead trout		5,000	
	Brook trout		17,000	
	Lake trout		1,790,000	
	Black bass, large-mouth			1,800
Wyoming	Black-spotted trout		5,000	
	Brook trout			5,000
Foreign countries:				
Italy	Quinnat salmon	50,000		
	Landlocked salmon	5,000		
	Rainbow trout	20,000		
Germany	Quinnat salmon	50,000		
	Steelhead trout	10,000		
Japan	Quinnat salmon	100,000		
France	Quinnat salmon	100,000		
	Rainbow trout	10,000		
Belgium	Landlocked salmon	10,000		
	Rainbow trout	10,000		
Portugal	Rainbow trout	10,000		
England	Rainbow trout	20,000		
	Brook trout	10,000		
Austria	Brook trout	10,000		
Switzerland	Brook trout	25,000		
	Lake trout	100,000		
Canada	Lake trout		257,250	
Mexico	Black bass, large-mouth			300
Totals		108,871,543	744,445,346	4,192,657

Details of distribution.

Species and disposition.	Eggs.	Fry and fingerlings.	Adults and yearlings.
Shad:			
Connecticut State Fish Commission, Lime, Conn		9,775,000	
Brandywine River, Wilmington, Del		9,479,000	
Smyrna Creek, Clayton, Del		780,000	
Leipsic Creek, Cheswold, Del		780,000	
St. John Creek, Dover, Del		840,000	
Murderkill Creek, Felton, Del		960,000	
Mispillion Creek, Milford, Del		780,000	
Blackbird Creek, Middletown, Del		420,000	
Indian River, Millsboro, Del		1,440,000	
Potomac River, near Aqueduct Bridge, D. C	5,179,000		
Potomac River, near Bathing Beach, D. C		50,000	
Potomac River, off Fish Lakes, D. C			3,036,000
Anacostia River, near Twining City, D. C		773,000	
Anacostia River, near Benning, D. C		894,000	
Chesapeake Bay, Battery Haul, Md	32,343,000	19,829,000	
Chesapeake Bay, off Battery Station, Md	13,552,000	4,489,000	
Chesapeake Bay, Havre de Grace, Md	5,611,000		
Chesapeake Bay, Back Channel, Md	358,000		
Chesapeake Bay, Western Shoals, Md	6,923,000		
Chesapeake Bay, Oakington Channel, Md	300,000	1,419,000	
Chesapeake Bay, Eastern Channel, Md	6,368,000		
Chesapeake Bay, Wild Duck, Md	900,000		
Chesapeake Bay, Perryville, Md		210,000	
Chesapeake Bay, Spesutia Narrows, Md		824,000	
Northeast River, Red Bank, Md	2,526,000		
Bush River, at Bush River Station, Md		2,500,000	
Gunpowder River, Gunpowder Station, Md		3,075,000	
Northeast River, Northeast, Md		1,200,000	
Wicomico River, Salisbury, Md		625,000	
Chester River, Chestertown, Md		625,000	
Tuckahoe Creek, Queen Anne, Md		625,000	
Swan Creek, Swan Creek, Md		450,000	
Susquehanna River, off Watson Island, Md		1,000,000	
Susquehanna River, Port Deposit, Md		800,000	
Elk Creek, Elkton, Md		800,000	
Mill Creek, Mill Creek, Md		1,000,000	
Potomac River, Bryan Point, Md		11,781,000	
Potomac River, off Chapman Bar, Md		4,001,000	
Potomac River, off Swan Creek, Md		1,717,000	
Potomac River, off Bar Landing, Md		1,796,000	
Potomac River, off Moxley Point, Md		3,287,000	
Potomac River, off Broad Creek, Md		2,102,000	
Potomac River, off Piscataway Creek, Md		1,712,000	
Parker Mill Ponds, Wareham, Mass		270,000	
Snipatuit Pond, Middleboro, Mass		270,000	
Salem Creek, Salem, N. J		600,000	
Manasquan River, Farmingdale, N. J		800,000	
Metedeconk River, Lakewood, N. J		800,000	
Toms River, Whites, N. J		800,000	
Delaware River, Milford, N. J		3,150,000	
Delaware River, Lambertville, N. J		4,500,000	
Delaware River, Burlington, N. J		460,000	
Delaware River, Port Jervis, N. Y		300,000	
Hudson River, Newburg, N. Y		2,500,000	
Hudson River, New York State Fish Commission, N. Y		3,000,000	
Albemarle Sound, Edenton, N. C	111,000	3,319,000	
Albemarle Sound, Mackey Ferry, N. C	1,700,000	713,000	
Perquimans River, Hertford, N. C		900,000	
Neuse River, Goldsboro, N. C		666,000	
Tar River, Tarboro, N. C		400,000	
Six Runs Creek, Elliott, N. C		534,000	
Northeast Branch of Cape Fear River, Wallace, N. C		400,000	
Susquehanna River, Peach Bottom, Pa		900,000	
Susquehanna River, Fites Eddy, Pa		450,000	
Delaware River, Bristol, Pa		6,000,000	
Delaware River, Delaware Water Gap, Pa		900,000	
Pee Dee River, Pee Dee, S. C		375,000	
Santee River, crossing Atlantic Coast Line R. R., S. C		388,000	
Santee Canal, crossing Atlantic Coast Line R. R., S. C		387,000	
Edisto River, Colleton County, S. C		309,000	
Ashepoo River, Colleton County, S. C		271,000	
Combahee River, Colleton County, S. C		270,000	
King Capsico River, Mount Holly, Va		300,000	
Nansemond River, Suffolk Va		715,000	
Potomac River, off White House, Va		781,000	
Potomac River, off Mount Vernon, Va		3,168,000	
Potomac River, Occoquan Bay, Va		8,552,000	
Potomac River, off Craney Island, Va		3,243,000	
Potomac River, off mouth of Pohick Creek, Va		2,546,000	
Potomac River, off Hunting Creek, Va		1,011,000	
Potomac River, off Colinwood, Va		918,000	
Potomac River, off Ferry Landing, Va		451,000	
Total	75,871,000	149,155,000	3,036,000

Details of distribution—Continued.

Species and disposition.	Eggs.	Fry and fingerlings.	Adults and yearlings.
Quinnat salmon:			
California Fish Commission, Sisson hatchery, Cal	22,255,000		
California Fish Commission, Eel River hatchery, Cal	8,000,000		
Olema Creek, Olema, Cal		850,000	
Papermill Creek, Olema, Cal		250,000	
Papermill Creek, Tocaloma, Cal		570,000	
Bear Valley Creek, Olema, Cal		250,000	
Sinoll Creek, Inverness, Cal		50,000	
Redwood Creek, Redwood Station, Cal		1,060,000	
Ulinor Creek, near Redwood Station, Cal		200,000	
Supply Creek, near Fort Gaston, Cal		16,000	
McCloud River, Baird, Cal		6,511,800	
Battle Creek, Battle Creek Station, Cal		5,885,500	
Long Pond, Bucksport, Me			29,691
Penobscot River, Orrington, Me			17,182
Penobscot River tributary, Prospect, Me			6,747
Brewer Pond, Bucksport, Me			19,982
Penobscot River, Millford, Me			4,994
Penobscot River, Bradley, Me			9,994
Sweet Pond, Orrington, Me			5,006
Penobscot River, Eddington, Me			7,485
Penobscot River, Brewer, Me			20,423
Penobscot River, North Milford, Me			2,493
Alamoosook Lake, Orland, Me			65,896
Toddy Pond, Surry, Me			27,816
Hancock Pond, Bucksport, Me			2,799
Heart Pond, Orland, Me			6,066
Toddy Pond, Orland, Me			3,032
Craig Pond, Orland, Me			200
Maine Fish Commission, Monmouth, Me	35,000		
Charles E. Oak, Caribou, Me	15,000		
Union River, Ellsworth, Me		901,066	
New England Sportsmen's Association, Boston, Mass			200
Lake Ontario, Tippet Point, N. Y		1,000	
St. Lawrence River, Cape Vincent, N. Y		2,033,000	
Salmon River, Pulaski, N. Y		328,000	
Lake Ontario, off Grenadier Island, N. Y		2,329,800	
Battery Park Aquarium, New York City, N. Y			200
Clackamas River and Clear Creek, Stone, Oreg		7,933,770	
Clackamas River, Stone, Oreg		2,076,026	
Clackamas River, Garfield, Oreg		4,390,000	
Salmon River, Salmon, Oreg		145,396	
Rogue River, Trail, Oreg		1,910,045	
Swing Creek, Mapleton, Oreg		85,000	
Siuslaw River, Mapleton, Oreg		280,000	
Sweet Creek, Mapleton, Oreg		75,275	
Wilson River, Wilson, Oreg		19,994	
Little White Salmon River, Chenowith, Wash		7,391,886	
Prof. D. Vinciguerra, Rome, Italy	50,000		
S. Jaffe, Sandfort, Germany	50,000		
M. Funohoshi, Niigatakeu, Japan	100,000		
Director Zoologique d'Acclimatation, Paris, France	100,000		
Total	30,605,000	45,543,558	230,200
Atlantic salmon:			
Connecticut Fish Commission, Windsor Locks, Conn	100,000		
Alamoosook Lake, Orland, Me			46,023
Toddy Pond, Orland, Me			78,844
Toddy Pond, Surry, Me		196,736	42,462
Craig Pond, Orland, Me			11,640
Penobscot River, Bangor, Me			2,495
Penobscot River, North Milford, Me			2,495
Penobscot River, Passadumkeag, Me		220,000	14,918
Heart Pond, Orland, Me			5,250
Green Lake, Otis, Me			16,208
Penobscot River, Milford, Me		150,000	
Penobscot River, Costigan, Me		160,000	
Penobscot River, Lincoln Center, Me		220,000	
Penobscot River, Mattawamkeag, Me		222,500	
Penobscot River, Winn, Me		170,000	
Long Pond, Bucksport, Me		119,051	
St. Croix River, Vanceboro, Me		137,500	
Williams Pond, Bucksport, Me		39,281	
Pleasant River, Brownville, Me		340,000	
New England Sportsmen's Association, Boston, Mass			100
State Fish Commission, Laconia, N. H	100,000		
Henry M. Davidson, Old Forge, N. Y	100,000		
Battery Park Aquarium, New York City, N. Y			200
St. Lawrence River, Cape Vincent, N. Y		97,071	
State Fish Commission, Allentown, Pa	100,000		
Total	400,000	2,072,139	220,635

Details of distribution—Continued.

Species and disposition.	Eggs.	Fry and fingerlings.	Adults and yearlings.
Landlocked salmon:			
Connecticut Fish Commission, Windsor Locks, Conn	10,000		
Duck Lake, Winn, Me			3,750
Sebec Lake, Dover, Me			2,500
Pearl Mill Stream, Brewer Junction, Me			3,750
Green Lake, Dedham, Me			421
Donnell Pond, Franklin Road, Me			5,000
Field Pond, Brewer Junction, Me			5,250
King and Bartlett lakes, Farmington, Me			3,000
Lake George, Skowhegan, Me			5,250
Lake George, Thorndike, Me			6,300
Bemis Creek, Bemis, Me			3,000
Alligator Lake, Great Pond, Me			1,000
Tunk Pond, Franklin Road, Me			1,500
Embden Lake, Oakland, Me			1,500
Brewer Pond, Brewer Junction, Me			1,500
Green Lake, Otis, Me			6,159
Toddy Pond, Orland, Me			1,960
Varnum Pond, Farmington, Me			3,300
Alford Lake, Rockland, Me			1,500
Half-mile Pond, Great Pond, Me			3,000
Lead Mountain Pond, Ellsworth Falls, Me			5,000
Hayden Lake, Skowhegan, Me			3,750
Moose Pond, Hartland, Me			3,000
Old Meadow Stream, Franklin Road, Me			5,000
Swan Lake, Belfast, Me			1,800
Richardson Lake, Rumford Falls, Me			1,800
Commodore Club, Hartland, Me	10,000		
Wild Goose Club, Wilson's Mills, Me	15,000		
Maine Fish Commission, Enfield, Me	41,243		
Podunk Pond, Brookfield, Mass			4,000
Pratt Pond, Upton, Mass			1,548
State Fish Commission, Winchester, Mass	10,000		
State Fish Commission, Detroit, Mich	10,000		
State Fish Commission, Laconia, N. H	10,000		
East Lake, Wakefield, N. H			5,000
Penacock Lake, Concord, N. H			5,000
A. M. Bigelow, Branchville, N. J	10,000		
J. D. Moreley, Lake Pleasant, N. Y	5,000		
Tuxedo Club, Tuxedo Park, N. Y	10,000		
Catskill Creek, Catskill, N. Y			6,000
Lake George, Caldwell, N. Y			4,800
Lake Champlain, Port Henry, N. Y			5,000
Battery Park Aquarium, New York City, N. Y			200
Eaglemere Lake, Eaglemere, Pa		3,085	
State Fish Commission, Westerly, R. I	5,000		
Easton Pond, Newport, R. I			1,550
State Fish Commission, Roxbury, Vt	10,000		
Caspian Lake, Greensboro, Vt		1,420	
Lake Morey, Fairlee, Vt		2,500	
Lake Willoughby, West Burke, Vt			2,000
Derby Pond, Newport, Vt			4,000
Salem Pond, Newport, Vt			2,000
State Fish Commission, Bayfield, Wis	10,000		
Prof. D. Vinciguerra, Rome, Italy	5,000		
Dr. R. Vandenhenden, Belgium	10,000		
Total	171,243	7,005	121,088
Steelhead trout:			
Redwood Creek, Bair's Ranch, Cal		650,000	
Commodore Club, Hartland, Me	50,000		
Alamoosook Lake, Orland, Me		10,032	6,172
Tributaries of Great Brook, Otis, Me		8,700	
Abraham and Molasses ponds, Eastbrook, Me		14,266	
Toddy Pond, Surry, Me		19,709	
Craig Pond, Orland, Me		2,200	
Heart Pond, Orland, Me		4,000	
New England Sportsmen's Association, Boston, Mass			200
Boardman River, Traverse City, Mich		10,000	
Hale Creek, Rose City, Mich		13,500	
Silver Creek, East Tawas, Mich		9,500	
Baldwin Creek, Baldwin, Mich		10,000	
Pere Marquette River, Baldwin, Mich		13,000	
Bear Creek, Thompsonville, Mich		10,000	
Cannon Creek, Williamsburg, Mich		5,000	
Little Manistee River, Manistee Crossing, Mich		10,000	
Washington River, Isle Royale, Mich		10,000	
South Fork of Pere Marquette River, Baldwin, Mich			500
Middle Fork of Pere Marquette River, Wingleston, Mich			1,000
Cold Creek, East Tawas, Mich			2,000
Pickwick Spring Lake, Lamoille, Minn		10,000	
Rolling Stone Creek, Winona, Minn		10,000	
Big and Little Trout brooks, Lamoille, Minn		10,000	

Details of distribution—Continued.

Species and disposition.	Eggs.	Fry and fingerlings.	Adults and yearlings.
Steelhead trout—Continued.			
Evans Lake, Duluth, Minn		5,000	
Lax Lake, Beaver Bay, Minn		5,000	
Temperance River, Temperance River, Minn		5,000	
Devil's Track River, Cook County, Minn		5,000	
Stewart River, Lake County, Minn		10,000	
French River, Duluth, Minn		10,000	
Sucker River, Duluth, Minn		15,000	
Lester River, Duluth, Minn		5,000	
State Fish Commission, St. Paul, Minn		25,000	
Mystic Lake, Mystic Lake, Mont			24,500
Willow Creek Lake, Pony, Mont			9,000
Applicants in Montana			10,000
Cocheco River, Dover, N. H		10,000	
Christine Lake, Stark, N. H		10,000	
Pleasant Pond, Manchester, N. H		10,000	
Big and Little Flat brooks, Branchville, N. J		12,800	
St. Lawrence River, Cape Vincent, N. Y		90,060	
Battery Park Aquarium, New York City, N. Y			200
Willoughby Lake, Westmore, Vt		4,975	
Lake Morey, Fairlee, Vt		2,498	
Missiquoi River, Swanton, Vt		2,703	
Lake Champlain, Isle La Motte, N. Y		24,411	
Crystal Lake, Barton, Vt		15,000	
Lake Champlain, Burlington, Vt		10,000	
Sleeper River, St. Johnsbury, Vt		1,000	
Brule River, Brule, Wis		5,000	
S. Jaffé, Osnabruck, Germany	10,000		
Total	60,000	1,113,354	53,572
Loch Leven trout:			
Capt. A. Rogers, Sisson, Cal	15,000		
Upper Twin Lakes, Lake County, Colo			8,000
Spring Pond, Lanier Heights, D. C		1,000	
St. Mary Lake, South Bend, Ind		5,000	
Cleveland Creek, Muskegon, Mich		3,000	
Applicants in New York		6,282	
Stranahan Bros., Hiram Station, Ohio	5,000		
Sucker Lake, Oswego, Oreg		3,000	
Clackamas River, Stone, Oreg		675	
Ladds Pond, Portland, Oreg		1,500	
Total	20,000	20,457	8,000
Rainbow trout:			
Lookout Lake, Gadsden, Ala			500
Spring Lake, Springville, Ala			300
Applicants in Alabama			200
Silver Creek, Holbrook, Ariz			1,000
Live Oak Creek, Flagstaff, Ariz			1,000
North Fork of White River, West Fork, Ark			3,000
North Fork of White River, Lilley, Ark			3,100
Frog Bayou, Mountainburg, Ark			3,000
Saline River, Benton, Ark			200
Applicants in Arkansas			1,900
Supply Creek, Hoopa Valley, Cal			2,755
Mill Creek, Hoopa Valley, Cal		9,985	1,230
Pine Creek, Weitchpec, Cal		11,950	
Fish Tangatang Creek, Trinity Summit, Cal		10,000	
Hennessey Creek, Burnt Ranch, Cal		3,950	100
Middle Evergreen Lake, near Leadville, Colo		5,000	
Applicants in Colorado		2,000	
State Fish Commission, for streams in State of Connecticut			800
State Fish Commission, Windsor Locks, Conn	25,000		
Tributaries of Delaware River, Wilmington, Del			570
Hermitage Heights Pond, Atlanta, Ga			500
Underwood Pond, Atlanta, Ga			300
Tallulah River, Blalock, Ga			1,000
Fouches Pond, Rome, Ga			500
Hiawassee River, Hiawassee, Ga			1,000
Head of Nottely River, Union County, Ga			1,000
Applicants in Georgia			500
Ballard Creek, Ballard Station, Ind. T			1,800
Barren Fork Creek, Barren Fork Station, Ind. T			1,750
Sallisaw River, Sallisaw, Ind. T			1,700
Applicants in Iowa		3,900	800
Mulberry Creek, Dodge City, Kans			950
Mill Pond in Buckner Creek, Jetmore, Kans			1,000
Laurel River, Corbin, Ky			1,100
Balkes Pond, Stine, Ky			500
Alamoosook Lake, Orland, Me			355
Bynum Run, Bellair, Md			500
Gunpowder River, Eklo, Md			500

Details of distribution—Continued.

Species and disposition.	Eggs.	Fry and fingerlings.	Adults and yearlings.
Rainbow trout—Continued.			
Spring Brooks, northwestern Maryland			1,000
Witt Creek, Cumberland, Md			750
Spring Brook, Finksburg, Md			500
Mountain Brook, Hagerstown, Md			500
Grave Run, Beckleysville, Md			500
Cherry Creek, in Garrett County, Md			905
Stony Run, Port Deposit, Md			500
Cabin Branch, Morgan, Md			1,000
Monocacy River, Dickerson, Md			500
Cabin Grant Creek, Florence, Md			700
Patuxent River, in Carroll and Montgomery counties, Md			800
Applicants in Maryland			1,850
State Fish Commission, Baltimore, Md	25,000		
Hamlin Pond, West Barnstable, Mass			1,000
Hadway Pond, Hyannis, Mass			660
Hinckley Pond, West Barnstable, Mass			1,000
New England Sportsmen's Association, Boston, Mass			20
S. R. Bennett, New Bedford, Mass	10,000		
Bear Creek and Miller Creek, Allegan, Mich			2,000
Sturgeon River, Rondo, Mich			2,000
Pere Marquette River, Baldwin, Mich			2,400
Pere Marquette River, Wingleton, Mich			800
Pere Marquette River, Stearns, Mich			800
Elm Springs, Fanning, Mo			986
Montgomery Lake, Osceola, Mo			1,900
Ash Cave Lake, Dixon, Mo			1,950
Five-mile Creek, Joplin, Mo			2,000
Shoal Creek, Neosho, Mo			354
Beaver Creek, Arlington, Mo			495
Spring Creek, Arlington, Mo			500
Hazleton Creek, Arlington, Mo			200
Indian Creek, Lanigan, Mo			4,800
Cowskin Creek, Noel, Mo			4,900
Minsey Lake, Forsyth, Mo			300
James River, Turner, Mo			1,000
Piney Creek, Cabool, Mo			1,000
Potter Creek, Cabool, Mo			1,000
Jack Fork of Current River, Mountain View, Mo			1,000
Bryan Fork of White River, Mansfield, Mo			1,000
Applicants in Missouri		5,000	1,820
Sac River and James River, Springfield, Mo		9,000	
Warm Spring Lake, Dillon, Mont		2,000	
Applicants in Montana		1,000	
Spring Brook and Lakes, Omaha, Nebr		4,000	2,000
State Fish Commission, South Bend, Nebr			12,000
Isinglass River, Dover, N. H		4,300	
Pequest River, Belvidere, N. J			500
Pequest River, Tranquillity, N. J			500
Frisa Pond, Williamstown, N. J			500
Applicants in New Jersey			500
Pecos River, Glorieta, N. Mex			950
Chama River, Chama, N. Mex			500
Lake Avalon, Eddy, N. Mex			175
Reservoir, Raton, N. Mex			475
Peekskill Hollow Creek, Peekskill, N. Y			300
Applicants in New York		2,200	200
Olympia Brook, Hunter, N. Y		5,000	
Mountain Stream, Peekskill, N. Y		5,906	
Brundage Creek, Johnsonville, N. Y		5,906	
Toe River, Cranberry, N. C			500
Laurel Creek, Asheville, N. C			500
Roaring Fork Creek, English, N. C			500
Briery Fork Creek, Calhoun, N. C			500
Shoal Creek, Calhoun, N. C			500
Allison Creek, Calhoun, N. C			500
Savannah Creek, Dillsboro, N. C			500
Dick Creek, Dillsboro, N. C			500
Catawba Creek, Marion, N. C			500
Armstrong Creek, Marion, N. C			500
Little Buck Creek, Marion, N. C			500
Watauga River, Lenoir, N. C			1,000
Valley River, Murphy, N. C			500
Plum Tree Creek, Cranberry, N. C			500
Caney Fork Creek, Sylva, N. C			500
Junaluska Creek, Andrews, N. C			500
Rocky River, Liberty, N. C			500
Rocky Creek, Wilkesboro, N. C			500
Elk River, Elk Park, N. C			500
Applicants in North Carolina			1,500
Lake Erie, Toledo, Ohio			300
Spring Bark Creek, North Enid, Okla			1,000

Details of distribution—Continued.

Species and disposition.	Eggs.	Fry and fingerlings.	Adults and yearlings.
Rainbow trout—Continued.			
Applicants in Oklahoma			3,100
Rambo Creek, Norristown, Pa			500
Kelkoin Run, Bedford, Pa			300
Clover Creek, Henrietta, Pa			760
Mountain Creek, Pinegrove Furnace, Pa			1,000
West End Creek, Alderson, Pa			500
Muddy Creek, York, Pa			300
West Branch of Shickshinny Creek, Shickshinny, Pa			500
Blair Run, Altoona, Pa			300
Neshameny Creek, Penllyn, Pa			300
Nescopec Creek, Upper Lehigh, Pa			500
Weisauking River, Rome, Pa			400
Stony Fork Creek, Cresson, Pa			300
Daly Brook, Smethport, Pa			250
Boyer Creek, Smethport, Pa			250
Cold Grove Brook, Smethport, Pa			250
Letort Spring, Carlisle, Pa			200
Beaver Run, Outlet Station, Pa			500
Potato Creek, Smethport, Pa			250
Indian Run, Smethport, Pa			250
Blacksmith Brook, Smethport, Pa			250
Robbins Brook, Smethport, Pa			250
Branch of Gunpowder Falls, New Freedom, Pa			300
Bluerock Creek, Hamburg, Pa			600
Rattlesnake Creek, Pittston, Pa			400
North Fork of Solomon Run, Johnstown, Pa			300
South Fork of Solomon Run, Johnstown, Pa			300
Hobliston Branch, Turnpike, Pa			300
Cobey Swamp Creek, Moosic, Pa			400
Webster Run, Mercersburg, Pa			300
Spring Brook, Lincoln University, Pa			600
Licking and Lost creeks, Mifflintown, Pa			300
Tea Brook, Reidsville, Pa			300
Coudersport Reservoir, Coudersport, Pa			800
Beaver Run, Westover, Pa			300
Norden Creek, Pittston, Pa			600
Fishing Creek, Lock Haven, Pa			2,500
Hay Creek, Birdsboro, Pa			300
Bailey Creek, Mansfield, Pa			300
Tioga River, Mansfield, Pa			200
Stone Creek, Huntingdon, Pa			300
Clover Creek, Altoona, Pa			300
Mahantong Creek, Shamokin, Pa			500
Elk Run, Johnstown, Pa			350
Kersey and Burns runs, Driftwood, Pa			500
Bear Valley Creek, Chambersburg, Pa			300
Falling Spring Creek, Chambersburg, Pa			400
Broadhead Creek, Cresco, Pa			1,500
Pennline Creek, Pennline, Pa			300
Conestoga Creek, Reading, Pa			200
Applicants in Pennsylvania			1,140
Tiger Creek, Morgan Springs, Tenn			500
Stone River, Murfreesboro, Tenn			500
Calf-killer River, Sparta, Tenn			500
Flint River, Fayetteville, Tenn			500
Duck River, Normandy, Tenn			1,000
Little River, Knoxville, Tenn			500
Little River, Notime, Tenn			500
Caney Fork River, Walling, Tenn			500
Tiger Creek, Hampton, Tenn			500
Green Brier Lake, Lebanon, Tenn			500
Dry Fork Creek, Greenville, Tenn			500
Roan Creek, Mountain City, Tenn			1,000
Shell Creek, Elizabethton, Tenn			500
Laurel Fork Creek, Hampton, Tenn			500
Applicants in Tennessee		225	1,631
Prairie Creek, Hutchins, Tex			800
Spring Creek, Dallas, Tex			1,500
Applicants in Texas			1,675
Silver Islet Lake, Park City, Utah		4,000	
Morse Pond, Montpelier, Vt			500
Beaver Ponds, Proctor, Vt			1,750
Clyde River, Derby, Vt		700	
Dart Creek, Winchester, Va			500
Buffalo Lake Run, Winchester, Va			500
Pohick Creek, Sideburn, Va			500
Thompson Mill Run, Millboro, Va			500
North River, Harrisonburg, Va			500
Mill Creek, Chilhowie, Va			2,200
Moomams Branch, Salem, Va			4,972

Details of distribution—Continued.

Species and distribution.	Eggs.	Fry and fingerlings.	Adults and yearlings.
Rainbow trout—Continued.			
Reed Creek, Rural Retreat, Va			1,000
South Fork of Holstein River, Marion, Va			5,000
Mill Pond, Gate City, Va			4,980
Cascade and Dums Creek, Hot Springs, Va			6,800
Coldspring Branch, Glasgow, Va			4,980
Brush Creek, Christiansburg, Va			5,000
Reed Creek, Wytheville, Va			10,000
Cove Creek, Wytheville, Va			6,969
Cripple Creek, Beverly Furnace, Va			5,000
Back Creek, New River, Va			500
Back Creek, Dublin, Va			500
Walker's Little Creek, Pulaski City, Va			500
Big Moccasin Creek, Gate City, Va			500
Perrow Mill Pond, Lynchburg, Va			200
Indian Camp Creek, Coleman Falls, Va			500
Branch of North Anna River, Hewlett, Va			500
Walker Creek, New River, Va			500
Gunstock Creek, Big Island, Va			500
Black Creek, Radford, Va			2,500
Tate Run, Wytheville, Va			2,200
South Fork of Reed Creek, Crocketts, Va			2,500
South Fork of Reed Creek, Wytheville, Va			2,000
Stony Fork of Reed Creek, Wytheville, Va			1,800
South Fork of Reed Creek, Browning's Dam, Va			350
Applicants in Virginia			17,025
Meadow Branch, Cherry Run, W. Va			500
Trout and Meadow Runs, Romney, W. Va			500
Laurel Run, Caldwell, W. Va			500
Willow Grove Lake, Shenandoah Junction, W. Va			200
Elk Creek, Clarksburg, W. Va			1,000
Applicants in West Virginia			700
Augusto Nobre, Villa Daconde, Portugal	10,000		
William Burgess & Co., Malvern Wells, England	20,000		
Prof. D. Vinciguerra, Rome, Italy	20,000		
Dr. R. Vandenhenden, Belgium	10,000		
M. Raveret-Wattel, Fecamp, France	10,000		
Total	130,000	96,022	249,532
Black-spotted trout:			
Tomichi Creek, Parlin, Colo		10,000	
St. Mary Lake, Idaho Springs, Colo		3,000	
Fall River, Idaho Springs, Colo		5,000	
Naylor Lake, Georgetown, Colo		10,000	
Fryingpan Creek, on line of Colorado Midland Railway, Colo		20,000	
Silver Lake, Dillon, Colo		5,000	
Bledsoe Lake, Leadville, Colo		5,000	
Mammoth Lake and Creek and Middle and South Boulder creeks, Central City, Colo		20,000	
Platte River, Grant, Colo		4,000	
Platte River, Slaght, Colo		4,000	
Platte River, Bailey, Colo		4,000	
Platte River, Crosson, Colo		4,000	
Platte River, Pine Grove, Colo		4,000	
Platte River, Buffalo, Colo		4,000	
Platte River, Dome Rock, Colo		6,000	
Rio Grande River, Wagonwheel Gap, Colo		15,000	
Eagle River, Berry Station, Colo		20,000	
Tomichi Creek, Elko, Colo		8,000	
Twin Lakes, in Lake County, Colo		35,000	
Headwaters of Eagle River, McAllister Switch, Colo		7,000	
Applicants in Colorado		6,000	
Spirit Lake, Rathdrum, Idaho		4,000	
Applicants in Idaho		4,000	
Agnes Lake, Brown, Mont		4,000	
Middle Creek, Bozeman, Mont		3,000	
Bridger Creek, Bozeman, Mont		7,000	
Rocky Canyon Creek, Bozeman, Mont		3,000	
Bitter Root River, Missoula, Mont		4,000	
Applicants in Montana		3,000	
Polo Creek, Deadwood, S. Dak		3,000	
Castle Creek, Hill City, S. Dak		3,000	
Harney Peak Fish Lakes, Hill City, S. Dak		2,000	
Woods Lake, Rapid City, S. Dak		3,000	
Collins Springs, Dell Rapids, S. Dak		2,400	
Applicants in South Dakota		1,000	
Applicants at Nashville, Tenn		3,000	
Spokane River, Spokane, Wash		5,000	
Heart Lake, Sheridan, Wyo		5,000	
Total		258,400	

Details of distribution—Continued.

Species and disposition.	Eggs.	Fry and fingerlings.	Adults and yearlings.
Brook trout:			
W. F. Whittier, Sisson, Cal	50,000		
E. C. Tallant, Sisson, Cal	10,000		
Capt. A. Rogers, Sisson, Cal	25,000		
Clohesey Lake, Granite, Colo			5,000
Quartz Creek, Pitkin, Colo			5,000
Little Ohio Creek, Ohio City, Colo			5,000
North Fork of Cache Lapoudre Creek, Tie Siding, Colo			3,000
South Boulder and Mammoth creeks, Central City, Colo			20,000
Rio Grande River, Wagonwheel Gap, Colo			10,000
Tomichi Creek, Buxton, Colo			5,000
East River, Crested Butte, Colo			5,000
Mill Creek Lakes, Wolcott, Colo			3,000
Eagle River, Red Cliff, Colo			5,000
Middle Evergreen Lake, near Leadville, Colo			16,600
Applicants in Colorado		41,000	9,000
Lake San Cristoval, Lake City, Colo		20,000	
Crystal River, Carbondale, Colo		10,000	
Anderson Lake, Monte Vista, Colo		10,000	
Snake River, Dillon, Colo		10 000	
Molas Lake, Silverton, Colo		10,000	
Horn and Mera creeks, Cotopaxi, Colo		10,000	
Cache Lapoudre Creek, Fort Collins, Colo		40,000	
White River, Rifle, Colo		10,000	
Sarles Lake, Rockwood, Colo		5,000	
Park Lake, Monte Vista, Colo		10,000	
Eagle River, Barry Station, Colo		25,000	
Dallas River and Cow Creek, Ridgway, Colo		10,000	
Spring Creek, Montrose, Colo		10,000	
South Arkansas River, Salida, Colo		10,000	
Fryingpan River, Norrie, Colo		40,000	
North Fork of Platte River, Estebrook, Colo		10,000	
Platte River, Estebrook, Colo		5,000	
Platte River, Deansbury, Colo		10,000	
Platte River, Bailey, Colo		5,000	
Platte River, Cassell, Colo		5,000	
South Platte River, Ferndale, Colo		10,000	
Buffalo Creek, Buffalo, Colo		10,000	
Rainbow Lake and Starbend Creek, Gunnison, Colo		10,000	
Elk Creek, Pine Grove, Colo		10,000	
Geneva Creek, Cassell, Colo		5,000	
Blood River, Breckenridge, Colo		10,000	
North Fork of South Platte River, Slaghts, Colo		10,000	
North Fork of South Platte River, Estebrook, Colo		5,000	
North Fork of South Platte River, Webster, Colo		5,000	
North Fork of South Platte River, Chaseville, Colo		5,000	
North Fork of South Platte River, Meadows, Colo		10,000	
North Fork of South Platte River, Brookside, Colo		10,000	
North Fork of South Platte River, Crosson, Colo		5,000	
North Fork of South Platte River, Cliff, Colo		2,500	
North Fork of South Platte River, Dawson, Colo		2,500	
Mountain stream at Bailey, Colo		10,000	
North Fork of Geneva Creek, Cassell, Colo		5,000	
Craig Creek, Estebrook, Colo		5,000	
Lake and stream at Monument, Colo		10,000	
Reservoir at Jefferson, Colo		5,000	
Beaver Creek, Aberdeen Junction, Colo		10,000	
Clear Creek, Silver Plume, Colo		10,000	
Half-moon Lake, Leadville, Colo		10,000	
Deer Creek, Bailey, Colo		10,000	
East River, Gunnison, Colo		10,000	
West Marshall Creek, Gunnison, Colo		5,000	
Silver Creek, Salida, Colo		5,000	
Alder Creek, Alder, Colo		5,000	
Kerby Creek, Villa Grove, Colo		5,000	
Union Creek, Malta, Colo		10,000	
North Clear Creek, Central City, Colo		3,335	
South Boulder Creek, Central City, Colo		3,335	
Middle Boulder Creek, Central City, Colo		3,333	
Jenny Lind Creek, Central City, Colo		3,333	
Mammoth Creek, Central City, Colo		3,332	
Mammoth Lakes, Central City, Colo		3,332	
Tennessee Fork Creek, Leadville, Colo		10,000	
West Aspetuck River, New Milford, Conn		15,000	
Five Mile River, South Norwalk, Conn		5,000	
State Fish Commission, Windsor Locks, Conn	10,000		
Blue Lakes, Shoshone, Idaho			5,000
Hawkes Creek, Westville, Ind		5,000	
Spring Branch, Laporte, Ind		5,000	
Spring Branch, South Bend, Ind		5,000	
Spring Creek, Orchard, Iowa		5,000	
Silver Lake, Mount Vernon, Iowa		2,000	
Baker, Baldwin, and Bigall brooks, Cresco, Iowa		10,000	

Details of distribution—Continued.

Species and disposition.	Eggs.	Fry and fingerlings.	Adults and yearlings.
Brook trout—Continued.			
Applicants in Iowa		1,700	2,000
Lake Anasagunticook, Canton, Me		10,000	
Varnum and Clearwater ponds, Farmington, Me		10,000	
Water Company Reservoir, Belfast, Me		5,000	
Old Meadow Brook, Franklin Road, Me		10,000	
Sandy and Half-moon brooks, Thorndike, Me		10,000	
Brewer Pond, Brewer Junction, Me		10,000	
Tributaries of Great Brook, Otis, Me		50,000	
Green Lake, Green Lake, Me		46,721	
Oxford Lake, Rockland, Me		10,000	
Field Pond, Brewer Junction, Me		10,000	
Lake George, Skowhegan, Me		10,000	
Narragaugus Pond, Franklin Road, Me		10,000	
Thompson Pond, Oxford, Me		15,000	
Tunk Lake, Franklin Road, Me		10,000	
Surry Pond, Ellsworth, Me		5,000	
Branch Pond, Dedham, Me		70,000	
Flood Pond, Otis, Me		20,000	
Patten Pond, Ellsworth, Me		35,000	
Bangor and Aroostook R. R. Pond, Shirley, Me		10,000	
Parmacheenee Club, Camp Caribou, Me	25,000		
Punchbowl Pond, Falmouth, Mass		5,000	
Hicks and Purgatory ponds, Millbury, Mass		10,000	
Mountain Rock Brook, Lowell, Mass		10,000	
Dunklin Hole, Dedham, Mass		10,000	
Wilson Creek, Dedham, Mass		10,000	
Pawessett Pond, Dedham, Mass		20,000	
Trule Brook, Lowell, Mass		5,000	
Applicants in Massachusetts		10,000	
Allen Creek, Bronson, Mich		10,000	
Paint Creek, Ypsilanti, Mich		5,000	
Spring Brook, Chesaning, Mich		5,000	
Sturgeon River, Gaylord, Mich		5,000	
Au Sable River, Grayling, Mich		100,000	
McMaster Creek, Onaway, Mich		10,000	
Hays Creek, Grass Lake, Mich		5,000	
Brule River, Iron County, Mich		10,000	
Iron and Brule rivers, Iron County, Mich		15,000	
Washington River, Isle Royale, Mich		5,000	
Applicants in Michigan			24
North Branch of Sunrise River, North Branch, Minn		5,000	
Poplar River, Lutsen, Minn		5,000	
Money Creek, Lamoille, Minn		5,000	
Pleasant Valley Creek, Lamoille, Minn		5,000	
Rush River, Winona, Minn		5,000	
Spring Brook, Northfield, Minn		10,000	
Colquet River, Duluth, Minn		5,000	
Five Springs, Lamoille, Minn		10,000	
Little Knife River and Silver Creek, Two Harbors, Minn		6,550	
Knife River, in St. Louis County, Minn		10,000	
Warm Bear Lake, Red Bluff, Mont			995
Odell Creek, Red Bluff, Mont			1,980
Cottonwood Creek, Bozeman, Mont			5,000
Trail Creek, Bozeman, Mont			5,000
Applicants in Montana			2,992
J. F. Comee, Missoula, Mont	2,000		
Spring Brook and Lakes, Omaha, Nebr			5,000
Spring Brook, East Grafton, N. H		20,000	
Christine Lake, Stark, N. H		9,975	
Merrimac County Fish and Game League, Concord, N. H		25,000	
State Fish Commission, Ashland, N. H	25,000		
A. M. Bigelow, Branchville, N. J	20,000		
Wm. Libbey, Princeton, N. J	300		
Charlotte Creek, Oneonta, N. Y		4,516	
Otego Creek, Oneonta, N. Y		4,516	
Crandall Brook, Greene, N. Y		4,516	
Tioughnioga River, De Ruyter, N. Y		4,516	
Big Brook, Adams Center, N. Y		4,516	
Montfreddy Brook, Syracuse, N. Y		4,516	
Shinglekill Creek, Cairo, N. Y		6,016	
Springbrook, Heartsdale, N. Y		6,016	
Cooper Brook, Peekskill, N. Y		3,668	
Moyer Creek, Frankfort, N. Y		4,516	
Trout Brook, Dexter, N. Y		4,516	
Horseshoe Pond, Horseshoe Pond, N. Y		4,516	
Little Moose River, Malone, N. Y		25,000	
Applicants in New York		2,808	
Brushy Fork of Licking River, Newark, Ohio		5,000	
Mad River, West Liberty, Ohio		4,000	
Mac-a-chee Run, West Liberty, Ohio		4,000	
North Branch of Owl Creek, Fredericktown, Ohio		5,000	

Details of distribution—Continued.

Species and disposition.	Eggs.	Fry and fingerlings.	Adults and yearlings.
Brook trout—Continued.			
Applicants in Ohio		11,000	
Stranahan Brothers, Hiram Station, Ohio	2,000		
Bear Creek, Medford, Oreg			2,300
Pine Creek, Hood River, Oreg			2,000
Panther Creek, Carlton, Oreg			2,000
Applicants in Pennsylvania			1,000
Pine, Spruce, and Baker runs, near Snowshoe, Pa		5,000	
Cockampany Brook, Wood River Junction, R. I		10,000	
Woods Lake, Rapid City, S. Dak			3,000
Applicants in South Dakota		21,000	3,500
Parley Canyon, Salt Lake City, Utah			5,000
Silver Islet Lakes, Park City, Utah			5,000
Applicants in Utah		5,000	2,000
State Fish Commission, Salt Lake City, Utah		15,000	
Grant Hampton, Salt Lake City, Utah	10,000		
Joseph H. Tuck, Salt Lake City, Utah	5,000		
L. C. Miller, Salt Lake City, Utah	5,000		
Edward McGurrin, Salt Lake City, Utah	5,000		
A. T. Godbe, Salt Lake City, Utah	5,000		
W. E. Miller, Salt Lake City, Utah	5,000		
J. H. Lundy, Salt Lake City, Utah	10,000		
George Manning, Salt Lake City, Utah	10,000		
G. J. Lund, Sugar Loaf, Utah	5,000		
Caledonia Club Pond, St. Johnsbury, Vt		25,000	
Tucker Brook, Woodstock, Vt		10,000	
Pico Pond, Sherburne, Vt		48,850	
Holland Pond, East Holland, Vt		10,000	
Griffith Pond, Danby, Vt		9,970	
Fairbanks Pond, St. Johnsbury, Vt		10,000	
Caspian Lake, Greensboro, Vt		49,910	
Darling Pond, Groton, Vt		100,000	
Spring Brook, Morrisville, Vt		10,000	
Lake Mitchell, Sharon, Vt		9,970	
Sleeper River, St. Johnsbury, Vt		36,000	
Applicants in Vermont		15,000	
Hon. T. N. Vail, Lyndonville, Vt	10,000		
State Fish Commission, Colebrook, N. H	10,000		
Caldwell and Little Spokane creeks, Spokane, Wash			4,000
Lake, New Whatcom, Wash			5,000
Applicant at Orilla, Wash			4,000
F. H. Cook, Spokane, Wash	25,000		
North Branch of Oconto River, Lakewood, Wis		5,000	
Black Oak Lake, State Line, Wis		5,000	
Plover River, Wausau, Wis		5,000	
Applicants in Wisconsin		2,000	
Dome Lake, Sheridan, Wyo			5,000
E. A. Schroder, Silesia, Austria	10,000		
Wm. Burgess & Co., Malvern Wells, England	10,000		
Swiss Government, Switzerland	25,000		
Total	319,300	1,863,798	161,391
Lake trout:			
State Fish Commission, Windsor Locks, Conn	300,000		
Spring Pond, Lanier Heights, D. C		1,000	
Geo. W. Rea, Arangee, Idaho	10,000		
Hudson Lake, South Bend, Ind		30,000	
Clear Lake, Clear Lake, Iowa		100,000	
Storm Lake, Storm Lake, Iowa		100,000	
Spirit Lake, Spirit Lake, Iowa		96,652	
Lake Okoboji, Spirit Lake, Iowa		92,652	
Silver Lake, Lake Park, Iowa		41,696	
Applicants in Iowa		10,000	
State Fish Commission, Enfield, Me	75,000		
Rocky Pond, Otis, Me		15,000	
Phillips Pond, Dedham, Me		30,000	
Applicants in Maine		10,000	
Green Lake, Ellsworth, Me		998	
State Fish Commission, Winchester, Mass	100,000		
Round Lake, Hanover, Mich		10,000	
Lake Huron, Alpena, Mich		29,800	
Lake Huron, off Thunder Bay Island, Mich		740,000	
Lake Huron, off Sugar Island, Mich		250,000	
Lake Michigan, Charlevoix, Mich		738,875	
Lake Michigan, Manistique, Mich		400,000	
Pine Lake, Charlevoix, Mich		408,875	
Twin Lakes, West Harrisonville, Mich		8,890	
Loon Lake, Hale Lake, Mich		8,960	
Crooked Lake, Lake George, Mich		10,000	
Little Star Lake, Baldwin, Mich		2,700	
Putnam Lake, Baldwin, Mich		7,700	
Bray Lake, Baldwin, Mich		2,600	
Straits of Mackinac, Mackinaw City, Mich		600,000	

Details of distribution—Continued.

Species and disposition.	Eggs.	Fry and fingerlings.	Adults and yearlings.
Lake trout—Continued.			
Straits of Mackinac, Cheboygan, Mich		400,000	
Long Lake, near Alpena, Mich		5,000	
Lake Superior, Grand Marais, Mich		400,000	
Lake Superior, Long Point, Mich		120,000	
Lake Superior, Washington Harbor, Mich		120,000	
Lake Superior, Fisherman's Home, Mich		120,000	
Lake Superior, off Wright Island, Mich		120,000	
Lake Superior, Rock Harbor, Mich		120,000	
Lake Superior, Chippewa Harbor, Mich		120,000	
Lake Superior, off Fish Island, Mich		120,000	
Lake Superior, Tobin Harbor, Mich		120,000	
Lake Superior, Todds Harbor, Mich		240,000	
Lake Superior, Ontonagon, Mich		500,000	
Crooked Lake, Lake Station, Mich		23,000	
Hamlin Lake, Baldwin, Mich		5,000	
Townsend Lake, Baldwin, Mich		3,500	
Mench Lake, Baldwin, Mich		6,500	
Cashren Lake, Baldwin, Mich		7,000	
St. Mary Lake, Sault Ste. Marie, Mich		400,000	
Black Bear Lake, Carlton, Minn		25,000	
Lake Superior, Chicago Bay, Minn		240,000	
Lake Superior, Grand Portage, Minn		240,000	
Lake Superior, Grand Marais, Minn		240,000	
Lake Superior, Poplar River, Minn		240,000	
Lake Superior, Beaver Bay, Minn		240,000	
Lake Superior, Two Harbors, Minn		240,000	
Lake Superior, French River, Minn		240,000	
Lake Superior, Duluth, Minn		8,000	
Wilson Bay, near Cape Vincent, N. Y		114,481	
Lake Ontario, off Cape Vincent, N. Y		62,700	
Lake Ontario, off Grenadier Island, N. Y		805,150	
Lake Oneida, Sylvan Beach, N. Y		18,640	
Henry Davidson, Old Forge, N. Y	200,000		
Lake Erie, Put-in Bay, Ohio		908,800	
Queens River, Kingston, R. I		8,000	
Lake Hendrick, White, S. Dak		20,000	
Applicants at Kimball, S. Dak		8,000	
Derby Pond, Derby, Vt		4,800	
Derby Pond, Newport, Vt		5,000	
Salem Pond, Derby, Vt		5,000	
Lake Dunmore, Salisbury, Vt		4,000	
State Fish Commission, Roxbury, Vt	200,000		
State Fish Commission, Colebrook, N. H	100,000		
Lake Michigan, Sheboygan, Wis		350,000	
Lake Superior, Bark Point, Wis		240,000	
Lake Superior, Sand Island, Wis		240,000	
Lake Superior, Raspberry Bay, Wis		240,000	
Lake Superior, Oak Island, Wis		240,000	
Lake Superior, Magdelena Island, Wis		480,000	
Lake Superior, near Lizard Island, Canada		17,250	
Lake Superior, Port Arthur, Canada		240,000	
Swiss Government, Switzerland	100,000		
Total	1,085,000	12,521,219	
Scotch sea trout:			
Alamoosook Lake, Orland, Me			1,489
New England Sportmen's Association, Boston, Mass			100
Total			1,589
Yellow-fin trout:			
Lower Twin Lakes, in Lake County, Colo		7,500	
Golden trout:			
Tributaries of Great Brook, Otis, Me		20,000	
Alligator Lake, Ellsworth Falls, Me		7,000	
Holbrook Pond, Holden, Me		7,000	
Branch Pond, Dedham, Me		20,000	
Flood Pond, Otis, Me		18,144	
State Fish Commission, Monmouth, Me	10,000		
State Fish Commission, Auburn, Me		7,000	
Total	10,000	79,144	
Grayling:			
Elk Creek, near Red Rock Lake, Mont		1,500,000	
Whitefish:			
Lake Huron, near Can Buoy, Mich		2,000,000	
Clear Lake, Valentine, Mich		500,000	
Lake Huron, near Thunder Bay Island, Mich		1,600,000	
Lake Huron, near Scarecrow Island, Mich		2,000,000	
Lake Huron, near Sugar Island, Mich		2,000,000	

Details of distribution—Continued.

Species and disposition.	Eggs.	Fry and fingerlings.	Adults and yearlings.
Whitefish—Continued.			
Lake Superior, Grace Harbor, Mich		98,000	
State Fish Commission, Ashland, N. H	200,000		
Lake Erie, near Put-in Bay, Ohio		56,990,000	
Lake Erie, Port Clinton, Ohio		17,720,000	
Lake Erie, Ottawa City, Ohio		5,580,000	
Total	200,000	88,488,000	
Pike perch:			
St. Lawrence River, near Cape Vincent, N. Y		9,243,750	
Raquette River, Potsdam, N. Y		800,000	
Lake Erie, Put-in Bay, Ohio		60,790,000	
Lake Erie, Port Clinton, Ohio		10,320,000	
Total		81,153,750	
Lake herring:			
Lake Erie, Put in Bay, Ohio		15,050,000	
Lake Erie, Port Clinton, Ohio		3,920,000	
Total		18,970,000	

Species and disposition.	Adults and yearlings.
Black bass, large-mouth:	
Clear Creek, Winslow, Ariz	200
Reservoir, Tucson, Ariz	100
Woodruff Fish Lake, Holbrook, Ariz	100
Applicants in Arizona	250
Ouachita River, Lawrence, Ark	200
Ouachita River, Arkadelphia, Ark	200
Clear Lake, Mayflower, Ark	200
Silver Springs Mill Pond, Rogers, Ark	200
Potash Sulphur Springs, Lawrence, Ark	100
Saline River, Benton, Ark	200
Applicants in Arkansas	1,150
Lake Maria, Cuchara Junction, Colo	300
Applicants in Las Animas, Colo	100
Little River, Seymour, Conn	200
Brandywine Lake, Wilmington, Del	400
Fish Club Lake, Carlyle, Ill	100
Lake Zurich, Barrington, Ill	250
Mill Pond, Charleston, Ill	100
Vermilion River, Danville, Ill	450
Crystal Springs Lake, Jacksonville, Ill	100
Illinois Central R. R. Co.'s Pond, Monee, Ill	150
Le Claire Lake, Edwardsville, Ill	100
Channel Lake, Antioch, Ill	50
Kishwaukee River, Belvedere, Ill	100
Des Plaines River, Des Plaines, Ill	100
Woodley Lake, Woodbury, Ill	50
Applicants in Illinois	475
Eagle Lake, Warsaw, Ind	50
Kent Pond, Kentland, Ind	250
Mill Pond, Kingsbury, Ind	300
Indian Creek, Bossert, Ind	25
Mill Pond, Kingsland, Ind	195
Salt Creek, Bedford, Ind	75
White River, Tunnelton, Ind	25
White River, Bedford, Ind	25
Guthrie Creek, Bedford, Ind	25
Leatherwood Creek, Bedford, Ind	50
Back Creek, Fort Ritner, Ind	25
Waterworks Lake, Booneville, Ind	25
Pine Creek, Walkerton, Ind	300
Pretty Lake, Plymouth, Ind	300
Eagle Lake, Eagle Lake, Ind	295
Cedar Lake, Cedar Lake, Ind	300
Lake James, Angola, Ind	480
Upper Salt Creek, Bedford, Ind	25
Falling Run Creek, New Albany, Ind	50
Furgason Lake, Knightstown, Ind	200
Sackritter, Kendallville, Ind	300
Applicants in Indiana	1,095
Applicants in Indian Territory	400
Iowa River, Iowa City, Iowa	100
Applicants in Iowa	100
Black bass, large-mouth—Continued.	
Applicants at Vinton, Iowa	100
Arkansas River, Great Bend, Kans	100
Eureka Lake, Manhattan, Kans	82
Carmichal Lake, Dodge City, Kans	100
Crystal Lake, Leavenworth, Kans	50
Forest Park Lake, Atchison, Kans	60
Valley View Lake, Lawrence, Kans	49
McDowell Creek, Manhattan, Kans	70
Forest Lake, Bonner Springs, Kans	35
Elmwood Lake, Bonner Springs, Kans	35
Buckner Creek, Jetmore, Kans	700
Pawnee Creek, Burdett, Kans	150
Lake Chanute, Olathe, Kans	25
Deer Creek, Atchison, Kans	30
Applicants in Kansas	1,555
Lake Gabriel, Holt, Ky	50
Little River, Hopkinsville, Ky	300
Dick River, Danville, Ky	50
Natural Bridge Lake, Natural Bridge, Ky	80
Nolin Creek, Hodgensville, Ky	50
Lake Ellerslie, Lexington, Ky	100
Lover's Lake, Hardenburg, Ky	50
Waterworks Reservoir, Junction City, Ky	50
Stony Creek, Paris, Ky	50
Rockbridge Lake, Lawrenceburg, Ky	50
Crystal Lake, Ryland Station, Ky	50
Illinois Lake, Paducah, Ky	100
Fennessy Lake, Culvertson Station, Ky	75
Applicants in Kentucky	480
Duck Pond, Crownsville, Md	100
Gunpowder River, Parkton, Md	200
Gunpowder River, Alesia, Md	200
Patuxent River, Laurel, Md	200
George Run, Parkton, Md	200
Keeney's Mill Pond, Freeland, Md	200
Little and Big Youghiogheny River, Oakland, Md	500
Potomac River, Woodmont, Md	1,200
Rock Creek, Kensington, Md	670
State Fish Commission, Baltimore, Md	6
Applicants in Maryland	250
Scargo Lake, Yarmouth, Mass	200
Elbow Pond, Buzzards Bay, Mass	430
New England Sportsmen's Association, Boston, Mass	10
Black River, Cheboygan, Mich	100
Big Lake, Evart, Mich	100
Pine Lake, Detroit, Mich	100
Hamlin Lake, Luddington, Mich	50
Pleasant Lake, Leslie, Mich	400
Round Lake, Hanover, Mich	400

Details of distribution—Continued.

Species and disposition.	Adults and yearlings.
Black bass, large-mouth—Continued.	
Cass River, Marlette, Mich	100
Base Lake, Dexter, Mich	150
Applicants at Ypsilanti, Mich	150
Clear Lake, Waseca, Minn	300
Silver Lake, Battle Lake, Minn	100
Lake Tetonka, Waterville, Minn	300
Caribou Lake, Duluth, Minn	50
Twin Lakes, Kansas City, Mo	50
Branch of Wilson Creek, Springfield, Mo	300
Sac and James rivers, Springfield, Mo	300
Silver Lake, Cedar Gap, Mo	100
Reservoir, Moberly, Mo	200
Five Mile Creek, Joplin, Mo,	100
Valle Lake, Ste. Genevieve, Mo	500
Dry Fork Creek, Carthage, Mo	200
White River, Forsyth, Mo	185
Applicants in Missouri	700
Applicants in Nebraska	130
Lake Hepatcong, Mount Arlington, N. J	200
C. A. Shriver, State fish commissioner, Jersey City, N. J	2,000
Applicants in New Jersey	150
Paloduro Canyon Creek, Salt Lake, N. Mex	200
Applicants in New Mexico	300
Greenwood Lake, Orange Co., N. Y	800
Summit Ave. Lake, Greensboro, N. C	150
Chockoyotte Creek, Weldon, N. C	100
Poplar Lake, Reidsville, N. C	150
Rocky Creek, Statesville, N. C	100
Applicants at Asheville, N. C	100
Square Butte Creek, Mandan, N. Dak.	250
Devil Lake, Devil Lake, N. Dak	260
Spirit Wood Lake, Jamestown, N. Dak	800
Park Lake, Mayville, N. Dak	100
Lake Metigoshe, Bottineau, N. Dak	180
Willow Lake, Rolla, N. Dak	75
Lake Irvine, Church Ferry, N. Dak	185
Rise Lake, Minot, N. Dak	100
Minnehaha Lake, Rolla, N. Dak	100
Mineral Springs, Rolla, N. Dak	50
Sheyenne River, Valley City, N. Dak	300
Long Lake, Bismarck, N. Dak	100
Church Spring, Inkster, N. Dak	50
Stump Lake, Lakota, N. Dak	260
Applicants at Davenport, N. Dak	200
Cliff Lake, Springfield, Ohio	100
Lake Idlewild, Kenton, Ohio	100
Tuscarawas River, Zoar, Ohio	150
Rosemoor Lake, Oxford, Ohio	50
Stillwater Creek, Troy, Ohio	100
Crystal Lake, Ravenna, Ohio	100
Olantangy River, Mt. Gilead, Ohio	150
Lake Epworth, Bethesda, Ohio	50
Hocking River, Athens, Ohio	100
Clear Fork Creek, Bellville, Ohio	100
Congress Lake, Congress Lake, Ohio	150
Wyoga Lake, Cuyahoga Falls, Ohio	100
Applicants in Ohio	986
Spring Branch, North Enid, Okla	100
Cheadle Creek, Guthrie, Okla	100
Mosquito Creek, Higgins, Okla	100
Canadian River, Shawnee, Okla	100
Spring Lake, Woodward, Okla	100
Applicants in Oklahoma	2,000
York Pond, Kingston, R. I	500
Charles W. Willard, State fish commissioner, Westerly, R. I	500
Maschang Pond, Westerly, R. I	300
Sheldon Reserve Pond, Sheldon, S. C	100
Castle Hill Reserve Pond, Yemassee, S. C	100
Applicants in South Carolina	300
Wautauga River, Johnson City, Tenn	100
French Broad River, Del Rio, Tenn	100
Spring Lake, Templeton, Tenn	50
Sulphur Fork Creek, Cedar Hill, Tenn	450
Black bass, large-mouth—Continued.	
Yellow Creek, Cave Mills, Tenn	100
Big Pigeon River, Newport, Tenn	100
Hill's Creek, McMinnville, Tenn	100
Elk River, Fayetteville, Tenn	100
Little Pigeon River, Knoxville, Tenn	200
Cane Creek, Fayetteville, Tenn	100
Corley Creek, Mae, Tenn	100
Mill Pond, Ætna, Tenn	100
Spring Brook, Doyal, Tenn	70
Chickamauga Lake, Chattanooga, Tenn	100
Green Lake, Chattanooga, Tenn	100
Short Creek and Pigeon Roost Creek, Cookeville, Tenn	200
Clear Fork River, Rugby Road, Tenn	100
Big Spring Creek, Church Grove, Tenn	100
Little Sequachee River, Sequachee, Tenn	100
Applicants in Tennessee	396
Sweetwater Creek, Miami, Tex	500
Timber Lakes, Clarendon, Tex	100
Paloduro Creek, Amarillo, Tex	200
Comal Spring and River, New Braunfels, Tex	450
Groesbeck Creek, Quannah, Tex	50
Lee Creek, Miami, Tex	300
Ranner Springs, Buffalo, Tex	100
Lampasas River, Lampasas, Tex	400
Catfish Lake, Tyler, Tex	200
Chapman Lake, Fort Worth, Tex	150
Oakland Lake, Denton, Tex	200
Tucker Lake, Tyler, Tex	200
Lake Park Lake, Tyler, Tex	200
Sulphur Branch, Rockland, Tex	400
Reservoir, Tioga, Tex	150
Houston and Texas Central R. R. Pond, Bremond, Tex	367
Walton Lake, Granger, Tex	75
Concho River, San Angelo, Tex	250
Santa Clare Creek, Marion, Tex	200
Menger Creek, Boerne, Tex	100
Fossil Creek, Fort Worth, Tex	150
Hurst Lake, Fort Worth, Tex	250
Russell Creek, Miami, Tex	200
Spring Creek, San Angelo, Tex	200
Lake Como, Fort Worth, Tex	300
Trinity River, Fort Worth, Tex	550
Clear Creek, Fort Worth, Tex	100
Turkey Creek, Cline, Tex	100
Sabinal River, Sabinal, Tex	200
Chaptico Lake, Marshall, Tex	150
Sue Belle Lake, Marshall, Tex	150
Elmendorf Lake, San Antonio, Tex	150
Spivey Lake, Kerens, Tex	200
Fin and Feather Club's Lake, Dallas, Tex	150
San Felipe Creek, Del Rio, Tex	100
San Antonio River, Floresville, Tex	300
Lake Louise, Brenham, Tex	100
Leona and Nueces rivers, Uvalde, Tex	200
Bow Spring Lake, West, Tex	175
Lake McDonald, Austin, Tex	600
Richland Creek, Brownwood, Tex	200
Tidoroni Creek, Alice, Tex	150
Mill Pond, Dallas, Tex	100
San Antonio River, San Antonio, Tex	225
Houston and Texas Central R. R. Co. Pond, Allen, Tex	166
Houston and Texas Central R. R. Co. Pond, Richland, Tex	167
San Miguel Creek, Pearsall, Tex	75
Reservoir, Banquette, Tex	150
Guadaloupe River, Kerrville, Tex	150
Hines Springs, Buffalo, Tex	100
Llano River, Llano, Tex	150
Cleveland Lake, Sugarland, Tex	75
Comanche Creek, Marathon, Tex	100
Barton Creek, Clarendon, Tex	350

Details of distribution—Continued.

Species and disposition.	Adults and yearlings.
Black bass, large-mouth—Continued.	
Medina River, Medina, Tex	150
Terra Blanco Creek, Amarillo, Tex	100
Amarillo Creek, Amarillo, Tex	150
Spring Creek, Amarillo, Tex	100
Alamositas Creek, Channing, Tex	150
Trinity River Lakes, Palestine, Tex	300
Cheyenne Creek, Channing, Tex	100
Rita Blanco Creek, Channing, Tex	150
Clear Creek, Hempstead, Tex	150
Cedar Lake, Palestine, Tex	150
Buffalo Springs Creek, Texline, Tex	150
Dripping Springs Creek, Channing, Tex	150
Guadaloupe River, Comfort, Tex	300
Majores Creek, Channing, Tex	150
Truxillo Creek, Channing, Tex	150
Mill Pond, Llano, Tex	150
Turkey Creek, Taylor, Tex	300
Groesbeck Creek, Quannah, Tex	100
Old River Lake, Chapel Hill, Tex	200
Pridham Lake, Cuero, Tex	100
Little Rove Creek, Higgins, Tex	150
Ocean Lake, Wills Point, Tex	100
Goose Lake, Wills Point, Tex	100
Kelley Creek, Yoakum, Tex	200
Palestine Club's Lake, Palestine, Tex	100
Fort Worth and Denver City R. R. Co. Pond, Bellevue, Tex	200
Fort Worth and Denver City R. R. Co. Pond, Quannah, Tex	200
Fort Worth and Denver City R. R. Co. Pond, Wichita Falls, Tex	200
Elm Creek, Gainesville, Tex	100
Applicants in Texas	14,730
Sabin Lake, East Calais, Vt	450
Rappahannock River, Fredericksburg, Va	300
Linnwood Lake, Pulaski City, Va	100
Applicants in Virginia	800
West Fork of Monongahela River, Clarksburg, W. Va	300
Severus Lake, Minong, Wis	250
Pewaukee Lake, Waukesha, Wis	300
Elbow Lake, Amberg, Wis	250
Wisconsin Central R. R. Co. Pond, Waupaca, Wis	1,000
G. Grilsenbeck, Monterey, Mexico	300
Total	76,064
Black bass, small-mouth:	
Potomac River, Woodmont, Md	309
Elbow Lake, Buzzard Bay, Mass	30
Waterworks Reservoir, Norwalk, Ohio	20
C. W. Willard, State fish commissioner, Westerly, R. I	460
Applicants in Tennessee	65
Shenandoah River, Overall, Va	1,000
Total	1,884
Crappie:	
Applicant at Wilmington, Del	100
Applicants in Illinois	375
Lake Marie, Antioch, Ill	100
Indian Creek, Bossert, Ind	50
Salt Creek, Bedford, Ind	100
White River, Tunnelton, Ind	50
Guthrie Creek, Bedford, Ind	50
Leatherwood Creek, Bedford, Ind	125
Back Creek, Fort Ritner, Ind	50
Waterworks Lake, Booneville, Ind	50
White River, Bedford, Ind	50
Upper Salt Creek, Bedford, Ind	50
Applicants in Indiana	125
Iowa River, Iowa City, Iowa	100
Applicant at Vinton, Iowa	100
Crystal Lake, Leavenworth, Kans	25
Eureka Lake, Manhattan, Kans	30
Alfalfa Lake, Wichita, Kans	65
Crappie—Continued.	
Lake Chanute, Olathe, Kans	25
Applicants in Kansas	70
Fennessey Lake, Culvertson Station, Ky	100
Applicants in Kentucky	450
Amity Lake, Duluth, Minn	300
Applicant at Kansas City, Mo	25
Poplar Lake, Reidsville, N. C	100
Square Butte Creek, Mandan, N. Dak	45
Willow Lake, Rolla, N. Dak	25
Lake Irvine, Church Ferry, N. Dak	40
Applicant at Davenport, N. Dak	50
Sheldon Reserve Pond, Sheldon, S. C	100
Applicant at Bennettsville, S. C	150
Dutch River, Columbus, Tenn	100
Applicants in Tennessee	72
San Marcos River, San Marcos, Tex	50
Meadowbrook Creek, Charlottesville, Va	72
Total	3,369
Sunfish:	
Shaker Lake, Cleveland, Ohio	69
Rock bass:	
Clear Creek, Winslow, Ariz	200
Reservoir, Tucson, Ariz	200
Applicants in Arkansas	1,600
Vanno Lake, Wagoner, Ind. T	200
Applicants in Indian Territory	480
Pawnee River, Larned, Kans	159
Applicants in Kansas	1,841
Lake Ellerslie, Lexington, Ky	221
Applicant in Maryland	200
White River, Forsythe, Mo	500
Applicants in Missouri	300
Reservoir, Elsie, Nebr	200
Lake Avalon, Eddy, N. Mex	200
Chockoyotte Creek, Weldon, N. C	115
Cross Creek, Fayetteville, N. C	100
Beaver Creek, Fayetteville, N. C	100
Applicants in North Carolina	1,400
Chippewa Lake, Chippewa Lake, Ohio	300
Olantangy River, Mount Gilead, Ohio	125
Shaker Lake, Cleveland, Ohio	208
Waterworks Reserv'r, Norwalk, Ohio	57
Applicants in Ohio	250
Spring Branch, North Enid, Okla	200
Divers Lake, North Enid, Okla	200
Ivanhoe Lake, Shattuck, Okla	200
Spring Creek, Sand Creek, Okla	200
Meers Creek, Mangum, Okla	200
Applicants in Oklahoma	3,800
Conestoga Creek, Reading, Pa	100
Lake Popononing, Bethlehem, Pa	100
Jacobs Creek, Connellsville, Pa	100
Conococheague Creek, Mercersburg, Pa	100
Middle Creek, Selinsgrove, Pa	100
Middle Creek, Middleburg, Pa	100
Ridley Creek, Nudia, Pa	100
Conococheague Creek, Chambersburg, Pa	400
Schuylkill River, Norristown, Pa	200
Perkiomen Creek, Norristown, Pa	100
Lake Rowena, Cresson, Pa	100
Witmer Run, Berwindale, Pa	100
Clover Creek, Johnstown, Pa	60
Penn Line Creek, Penn Line, Pa	100
Applicants in Pennsylvania	550
Brook Pond, Rockhill, S. C	100
Applicants in South Carolina	400
Shell Creek, Elizabethton, Tenn	100
Yellow Creek, Cave Mills, Tenn	100
Little River, Knoxville, Tenn	150
Crooked Creek, Notime, Tenn	200
Applicants in Tennessee	886
Guadaloupe River, New Braunfels, Tex	200
Elmendorf Lake, San Antonio, Tex	350

Details of distribution—Continued.

Species and disposition.	Adults and yearlings.	Species and disposition.	Adults and yearlings.
Rock bass—Continued.		*Strawberry bass*—Continued.	
Balcomes Creek, San Antonio, Tex	200	Saline River, Benton, Ark	400
Llano River, Llano, Tex	200	Applicant at Ozark, Ark	200
Guadalupe River, Ganahl, Tex	200	Buckhorn Lake, Wynnewood, Ind. T	500
Lake Julia, Houston, Tex	200	Applicant at Ardmore, Ind. T	200
Applicants in Texas	2,350	Applicants at Sewell, Iowa	100
Buffalo Lick Run, Winchester, Va	100	Applicant at Upton, Ky	242
Carter Run, Warrenton, Va	100	Sac and James rivers, Springfield, Mo	300
Applicants in Virginia	1,150	Five-mile Creek, Joplin, Mo	100
Applicants in West Virginia	300	Valle Lake, Ste. Genevieve, Mo	400
		White River, Forsythe, Mo	500
Total	23,352	Applicants in Nebraska	70
		Lake Avalon, Eddy, N. Mex	500
Strawberry bass:		Paloduro Canyon Creek, Salt Lake, N. Mex	300
Clear Creek, Winslow, Ariz	100	Cliff Lake, Springfield, Ohio	25
Woodruff Fish Lake, Holbrook, Ariz	200	Crystal Lake, Ravenna, Ohio	50
Applicant at Wilcox, Ariz	100	Applicant at Cincinnati, Ohio	25
Ouachita River, Lawrence, Ark	200	Canadian River, Shawnee, Okla	200
Ouachita River, Arkadelphia, Ark	500	Applicant at Woodward, Okla	200
Clear Lake, Mayflower, Ark	300		
Potash Sulphur Springs, Lawrence, Ark	200	Total	5,912

Species and disposition.	Fry.	Species and disposition.	Fry.
Codfish:		*Lobster*—Continued.	
Massachusetts Bay, Gloucester	59,278,000	Gulf of Maine near—	
Vineyard Sound, near Robinson Hole, Mass	2,607,000	Southeast shore, Andrews Island, Me	1,000,000
Vineyard Sound off—		Greens Landing, Me	1,000,000
Cuttyhunk Island, Mass	8,961,000	Gulf of Maine off—	
Quicks Hole, Mass	13,760,000	Swan Island, Me	200,000
Gay Head, Mass	32,575,000	Cranberry Island, Me	200,000
Tarpaulin Cove, Mass	8,376,000	Gulf of Maine, north point of Matinid Island, Me	1,000,000
Atlantic coast waters—		Kittery Harbor, Kittery Point, Me	3,000,000
Gloucester, Mass	15,245,000	Casco Bay, between Hope and Crotch Islands, Me	1,200,000
Rockport, Mass	17,035,000	Johns Bay, near Johns Island, Me	1,500,000
Atlantic Ocean off—		Rockland Bay, near Seal Ledge, Me	500,000
Vineyard light-ship, Mass	3,654,000	Maine coast waters, York Beach	1,200,000
Gay Head, Mass	20,360,000	Casco Bay, off Bailey Island, Me	1,200,000
Vineyard Sound, off Cuttyhunk light, Mass	3,566,000	Prospect Harbor, Me	200,000
Buzzards Bay, near Robinson Hole, Mass	5,631,000	Jonesport Harbor, Jonesport, Me	200,000
Cape Cod Bay, off Race Point light, Mass	3,782,000	Cutler Harbor, Cutler, Me	200,000
Ipswich Bay, Rockport, Mass	5,149,000	Casco Bay, Small Point Harbor, Me	3,000,000
Vineyard Sound, mouth of Woods Hole Harbor, Mass	33,000	Massachusetts Bay—	
Cape Cod Bay, Provincetown, Mass	2,558,000	Gloucester, Mass	12,356,000
		Marblehead, Mass	950,000
Total	202,570,000	Beverly, Mass	595,000
Pollock:		Magnolia, Mass	4,125,000
Atlantic coast waters, Gloucester, Mass	978,000	Manchester, Mass	6,515,000
Massachusetts Bay, Gloucester, Mass	3,477,000	Massachusetts coast waters—	
		Rockport, Mass	7,800,000
Total	4,455,000	Gloucester, Mass	3,325,000
Flatfish:		Woods Hole Harbor, Mass	2,095,000
Woods Hole Harbor, Mass	33,364,000	Vineyard Sound, Gosnold, Mass	8,627,000
Waquoit Bay, Waquoit, Mass	5,973,000	Vineyard Sound, Woods Hole, Mass	8,459,000
		Vineyard Sound, Gay Head, Mass	415,000
Total	39,337,000	Waquoit Bay, Waquoit, Mass	208,000
Lobster:		Gloucester Harbor, Gloucester, Mass	4,751,000
Gulf of Maine near—		Buzzards Bay, Gosnold, Mass	5,072,000
Damascove Island, Me	500,000	Buzzards Bay, Woods Hole, Mass	612,000
George Island, Me	500,000	Buzzards Bay, New Bedford, Mass	512,000
Wheeler Bay, Me	500,000	Buzzards Bay, Quissett, Mass	1,672,000
Western Point, Richmond Island, Me	600,000	Ipswich Bay, Lanesville, Mass	1,080,000
Cape Elizabeth, Me	4,000,000	Boston Harbor, Boston, Mass	900,000
Northwest shore of Wood Island	600,000	Atlantic Ocean, off Vineyard Sound light-ship, Mass	1,265,000
		Portsmouth Harbor, New Castle, N. H	1,200,000
		Block Island Sound, near Block Island, R. I	1,200,000
		Total	95,234,000

NOTE. During the fiscal year 1898, 566 tautog, 271 lobster, and 162 blue crab were planted in the Pacific Ocean, near Farallone Islands, in the State of California.

REPORT ON THE INQUIRY RESPECTING FOOD-FISHES AND THE FISHING-GROUNDS.

By Hugh M. Smith, *Assistant in Charge.*

OYSTER INVESTIGATIONS.

LOUISIANA.

In May, 1897, a communication was received from Hon. Adolph Meyer, member of Congress from Louisiana, transmitting a resolution of the general assembly of that State requesting the Commission to make an investigation of the oyster-grounds of Louisiana. The special object of the desired investigation was to obtain information on which to base a revision of the oyster laws, with a view to place the oyster industry on a more substantial basis. The legislature was informed that the Commission would undertake the investigation at the earliest practicable date.

In August, 1897, Dr. H. F. Moore went to Louisiana to make some preliminary inquiries that could not be satisfactorily undertaken at any other season. It had been determined to detail the steamer *Fish Hawk* (Lieut. Franklin Swift, U. S. N., commanding) early in the winter for the proposed investigation, but the vessel could not reach the field of operations before February 2, 1898, and the time available for this work was curtailed by the exigencies of the annual shad-hatching operations of the *Fish Hawk* on the Atlantic coast, so that only 21 days could be devoted to the examination of the oyster-grounds, which time was somewhat further reduced by stormy weather.

It being apparent that only a limited area could be surveyed in the time available, the oyster-beds of St. Bernard Parish were selected as presenting the most satisfactory features for examination. This parish comprises the extreme eastern part of Louisiana and contains some of the most important oyster-beds of the State. Owing to the shallowness of the water over the greater part of the region it was impossible to make use of the steamer for the active work of the survey, and this duty was therefore performed entirely by the two launches, the ship being used as a base. The limited time at the disposal of the party made it impossible to erect signals and make a regular survey, such as was originally contemplated, but by engaging pilots and running lines of soundings from point to point it was possible to make a reconnaissance showing the main hydrographic features and the general location and extent of the oyster-beds. The work was carried on over an area of about 200 square miles, and as it was sometimes necessary to run

long distances from the ship much time was lost. Should the work be again taken up, with a view to making a finished survey, it would be desirable to obtain one or two light-draft sailing vessels, which could be taken into the interior waters to serve as bases of operation and living quarters for the field parties using the launches.

The survey was under the direction of Lieutenant Swift, who was assisted by Dr. Moore as zoologist. After the *Fish Hawk* left Louisiana waters, on February 26, Dr. Moore remained and made a rapid examination of the remaining oyster-grounds of the State.

The oyster-beds of Louisiana lie principally between Mississippi Sound and the mouth of the Atchafalaya, the only beds to the westward of the latter place being comparatively unimportant ones in the vicinity of Vermilion Bay and Calcasieu River. The most productive natural beds at present are in St. Bernard and Terrebonne parishes, the latter being the most important oyster region in the State.

There is ample evidence that some of the practices now and formerly in vogue are detrimental to the best interests of the State and have resulted in the practical extermination of the oyster in certain regions in which it was formerly abundant. Dr. Moore's report upon this investigation, which will be transmitted to the Louisiana authorities, contains suggestions concerning the laws and methods necessary to secure the growth and welfare of the industry, and also deals with the history, condition, and prospects of the oyster-grounds. It will be found in the appendix to this volume (pp. 45–100), accompanied by a chart showing the location of the oyster-beds of St. Bernard Parish.

The oyster-planting industry is capable of great expansion within the limits of Louisiana. At present planting is practically confined to Plaquemines Parish, where a rather crude method of oyster-culture has been found to yield satisfactory profits and is now engaged in by a considerable number of persons. Practically all of the oysters sold from this parish, most of which are put on the market as "Bayou Cooks," are planted—generally as seed obtained from the natural beds, but sometimes as spat caught on artificially distributed shells.

The rather limited biological investigation of the Louisiana oyster which it has been possible to make indicates that it spawns during nearly all the year, but most of the spawn is undoubtedly expelled between April 1 and September 15. The rate of growth is rapid and there are doubtless few places in the State in which oysters will not reach a good marketable size within three years from the time of spawning.

The principal enemies of the oyster in Louisiana are the drumfish (*Pogonias cromis*) and a snail (*Melongena?*). Other foes do a limited amount of damage, but the starfish and drill (*Urosalpinx*), which create such havoc on the beds of the North, are here practically unknown as destructive agents. Storms and crevasses occasionally prove very injurious to the oyster-beds of the State, but crevasses are often followed by a peculiar process of regeneration (not satisfactorily explained) which soon renders the beds more productive than before. This phe-

nomenon, concerning which there can be no doubt, seems to occur with sufficient frequency to convince the oystermen that a crevasse is a desirable thing in the case of semidepleted beds.

The density of the water on the coast of Louisiana undergoes great fluctuation, being largely conditioned by the direction of the prevailing wind and the amount of precipitation. In general it is lower in winter than in summer. In the bays, bayous, and lagoons it is increased by southerly or (east of the Mississippi) easterly winds, and lowered by northerly winds and rains.

LYNNHAVEN BAY, VIRGINIA.

The experiments, in charge of Dr. H. F. Moore, begun during the last fiscal year at Lynnhaven, Va., looking toward a practical solution of the difficulties encountered in fattening oysters for market, have been continued without as yet having reached definite results. The claire established there has now been in operation about a year, during which time it has been cut off from accessions of sea water excepting during high tide, such as occurs several times during each month. On two occasions the claire has been flooded to a depth of several feet above the dam crest by extraordinary storm tides. Oysters have been kept in the claire during the entire period of the experiment, and from time to time others have been placed in several parts of the pond, but none of them has developed a condition superior to those in the open waters of Lynnhaven Bay, and most of them are decidedly inferior. It appears that in this particular case there is no advantage to be gained by simply inclosing a cove or pond after the method which has been attended with marked success in Europe. The conditions in this pond, therefore, can not be held to favor the experiment, and if it can be demonstrated that the food-producing powers of this claire can be materially increased by artificial means an important advance in oyster-culture will have been made.

Laboratory experiments appear to indicate that artificial conditions can be established which will tend to increase the rapidity of multiplication of the diatoms upon which the oyster mainly subsists, and it now remains to adapt the same experiments to the larger body of water contained in the claire. That this can be done is by no means clear, as certain intermediate attempts during the past year have yielded contradictory and unsatisfactory results, and it may take a long time to perfect the proper methods. It is proposed to continue the experiments during the coming year.

PACIFIC COAST.

The acclimatization of the eastern oyster (*Ostrea virginica*) on the Pacific coast and its subsequent increase by natural propagation would prove a great boon to an extensive section; and the Commission has made a number of experiments to test the adaptability of the shores of the Pacific States to the growth of this mollusk.

As is well known, transplanted eastern oysters have been successfully grown in San Francisco Bay for many years.* In October, 1894, 80 barrels of oysters, from New York, New Jersey, and Chesapeake Bay, were planted by the Commission in Willapa Bay, Washington;† and in November, 1896, 25 barrels of 3-year-old and 4-year-old oysters from Princess Bay and East River, New York, were deposited in Humboldt Bay, California, and an equal quantity in Yaquina Bay, Oregon.

In Yaquina Bay the oysters were deposited on Oysterville Flat, 2 miles above Yaquina City and about 7 miles from the ocean, and were spread over an area of about half an acre, the bottom consisting of mud and shells. The flat is a natural bed of the native oyster (*Ostrea lurida*) but has been so closely worked that oystering is no longer profitable; at low tide it is covered with 10 feet of water and at high tide with 18 to 20 feet. During the spring and summer of 1897 Prof. F. L. Washburn of the State University at Eugene, Oreg., was engaged by the Commission to examine the beds of eastern oysters that had been planted in Yaquina Bay in the previous year, and also to study the physical conditions of other bodies of water on the Oregon coast with reference to the introduction of the Atlantic oyster. His observations showed that the transplanted oysters exhibited considerable growth, and were in a spawning state. Many million eggs were artificially fertilized and the embryos released in the waters of the bay.

No spat of the eastern oyster was discovered up to the close of the season's inquiries on September 12, but an abundant "set" of the native oyster was observed on the shells of the introduced species. Sufficient time has not yet elapsed to demonstrate whether the waters are adapted to the multiplication of the Atlantic oyster, and three or four years might be required in order to definitely settle the matter. The most serious condition to which the spat would be subjected seems to be the sudden and marked variation in the salinity of the water, owing to changes in the tide, strong winds from the ocean, and heavy rainfall.

Examinations of some other bays on the Oregon coast with reference to their suitability for eastern oysters showed that Coos Bay was too salty for successful growth except near Marshfield, where the oysters might suffer from freshets and sewage; that Tillamook Bay was very salt and cold except at its extreme head, where mud and fresh water would kill the oysters during winter; and that the water of Netarts Bay was too dense.

An examination of the waters at Gearhart Park, on the ocean adjacent to Astoria, at the request of Mr. M. J. Kinney, the well-known salmon-canner, disclosed no localities in which oyster-culture is feasible.

It is proposed to have Professor Washburn continue his observations on the planted oysters in Yaquina Bay during the fiscal year 1898–99.

* See "Report of observations respecting the oyster resources and oyster fishery of the Pacific coast of the United States." By C. H. Townsend. Report U. S. Fish Commission, 1889–91.

† "The transplanting of Eastern oysters to Willapa Bay, with notes on the native oyster industry." By C. H. Townsend. Report U. S. Fish Commission, 1895.

The physical features of Humboldt Bay, California, seem unfavorable for oysters, the salinity of the water being almost as great as in the ocean, and the summer temperature being too low to warrant the free development of eggs. Furthermore, starfish and stingrays are reported as destructive, and Professor Washburn found one starfish with an eastern oyster in its grasp. The plants were in only fair condition in August, and but few showed spawn, thus contrasting strongly with the Yaquina Bay oysters.

GREEN OYSTERS.

During the season of 1897–98, the oysters in the lower Chesapeake basin, notably at Lynnhaven Bay, Va., were affected with green gills, which condition, by rendering the crop unmarketable for the time being, was financially very serious to the oystermen. At Lynnhaven the first indications of this affection were noticed in June, 1897. The color at that time was quite faint, and had completely escaped the notice of the oystermen, but it gradually grew in intensity, until by the first of September it had become extremely pronounced. At the opening of the season (in September) a few oysters were shipped, but the greenness proved so repugnant to the consumers that the demand soon entirely ceased, and practically no oysters were shipped from Lynnhaven during the remainder of the season.

The Commission received a large number of inquiries from boards of health, boards of trade, oyster-dealers, and oyster-fishermen regarding the wholesomeness of green oysters. It is the popular opinion that green-gilled oysters owe their viridity to the presence of copper, and are therefore unwholesome; and this view has been recently strengthened by newspaper references to a paper by two eminent English investigators, Prof. Rupert Boyce and Dr. W. A. Herdman, in which they record the discovery of copper in unusual quantities in certain green American oysters in England. Stimulated by this discovery, a reexamination of the question was begun by Dr. H. F. Moore, but has not yet been completed, owing to the intervention of other duties. Enough has been accomplished, however, to show conclusively that the green color of the oysters at Lynnhaven was not produced by copper. All of the customary tests were applied without securing a copper reaction, and specimens of the green oysters were submitted for quantitative tests to Prof. J. D. Hird, of the Medical Department of Georgetown University, who found mere traces of copper, and reported that "the green color was due to a hydrated ferrous compound." The exact source of the green color has not been satisfactorily determined, but in no case is it injurious.

All attempts to obtain the pigment in solution have failed, and, like "marennin," as Lankester has named the substance which produces the characteristic green color of the oysters of Marennes, it is insoluble in alcohol, ether, benzole, benzine, glycerin, water, dilute alkalies, and dilute acids.

The diatom *Navicula ostrearia*, which produces the green pigment investigated by Lankester and others, was not found in the Lynnhaven oysters, and the stomach contents presented the same golden-brown coloration commonly found in normal oysters. It is evident that this greenness is quite different from that investigated by Boyce and Herdman,* and before them by Ryder. The green color was confined to the gills and palps, and no pigment whatever was found in the heart, pericardium, or blood cells. Practical tests have shown that these oysters may be safely eaten in large quantities.

RED OR "BLOODY" OYSTERS.

During the oyster season of 1896–97, the oysters on certain parts of the Virginia coast were affected with a peculiar condition which has heretofore been very rarely observed in this section. In making a canvass of the oyster industry of the State in the spring of 1898, Mr. W. A. Wilcox, agent of the Fish Commission, secured the following information regarding the extent and appearance of the affection: It seems to have been first noticed in the season of 1895–96, when a few oysters from the upper oyster-grounds in the Rappahannock River were found to have a reddish color, and received the local name of "bloody oysters." At the outset the grounds involved were not extensive, but by the next season most of the beds down the river were affected, as well as numerous adjacent smaller-water courses in Lancaster and Middlesex counties and a limited area in Chesapeake Bay off the mouth of the river.

It is reported that there were "bloody" oysters also on the shores of Chesapeake Bay north of the mouth of the Potomac. Information has been received indicating the occurrence of a similar condition in parts of Chesapeake Bay about ten years ago.

When these oysters were examined in October, 1896, the red discoloration involved only the region of the gills, but a little later it extended throughout the oyster and its liquor. During the early spring of 1897 the color gradually disappeared; by the close of the season few, if any, red oysters were to be found, and none has since been reported.

The existence of red oysters in the Rappahannock region resulted in a serious disturbance of the oyster fishery and trade. The greatest pecuniary loss was due to the prejudice which arose against the oysters from the affected districts, the fear being generally entertained that those which seemed normal when first gathered might develop the red color before reaching the consumer. In some instances cargoes of oysters that on close inspection were entirely normal would, on arriving at Norfolk or other markets, show the reddish color, which gradually involved the entire cargo, necessitating the return and replanting or the throwing away of the oysters.

In conversation with Norfolk oyster-dealers, the writer was informed

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*On a green leucocytosis in oysters, associated with the presence of copper in the leucocytes.—Proceedings of the Royal Society, vol. 62.

that about 50,000 bushels of such oysters were brought to that city during the season of 1896-97.

The red oysters seemed to be fat and well flavored, the few persons who ventured to eat them reporting no ill effects.

The nature of this affection could not be determined, as no opportunity to examine the oysters was afforded the Commission, nor does the condition seem to have been previously described. Possibly the infusorian *Peridinium*, which gives a reddish color to sea water and is occasionally reported on the Atlantic coast, may be the cause.

SPONGE FISHERY OF FLORIDA.

In January, 1898, the writer visited Key West, Florida, in order to obtain information concerning the present condition and recent changes in the Florida sponge fishery and trade which center at this place. Data were furnished by the purchasing firms showing the quantities of sponges landed by the fishing vessels in the years 1896 and 1897. By correspondence and other means, similar figures were secured from dealers at the other sponge centers of the State. The Commission having in 1896 canvassed the sponge industry for the preceding year, a continuous record was thus acquired giving the sponge catch for the three years ending 1897, during which some marked changes in production were manifested. The results of the inquiries were incorporated in a report* by the writer presented at the National Fishery Congress, held at Tampa, Fla., in January, 1898.

The investigation shows that in 1897 the Florida sponge fishery yielded 331,546 pounds of sponges, having a first value of $284,640; in the previous year 234,111 pounds, worth $273,012, and in 1895 306,120 pounds, valued at $386,871. The condition of the fishery can not be accurately gauged from the foregoing bare figures, which show a larger yield in 1897 than in 1895 or 1896, although it is known that the industry, as a whole, was in a declining state. The explanation is that the catch in 1897 consisted of a much larger percentage of the lower grades of sponges. Thus, the output of the comparatively cheap grass sponges (having an average value of only 23 cents a pound) increased from 7 per cent of the aggregate catch in 1895 to 19 per cent in 1896 and 39 per cent in 1897; while the yield of the most valuable sponge, the sheepswool (average value $1.53 per pound), declined from 76 per cent in 1895 to 64 per cent in 1896 and 47 per cent in 1897.

It is the almost unanimous opinion of those who have given the matter careful attention that the sponge-grounds of Florida, while still very productive, are being seriously depleted; and the fact is generally recognized that a continuance of the present conditions will in a short time result in great loss to those having capital invested in vessels, equipment, and warehouses.

*The Florida Commercial Sponges. By Hugh M. Smith. Bull. U. S. Fish Commission 1897, pp. 225-240, 20 plates.

The following facts may be cited in evidence of a decline in the abundance of sponges: Grounds along the Florida coast that were formerly very productive (and in fact yielded most of the supply) have been completely abandoned, although the industry is not 50 years old. The spongers have had to resort to deeper and deeper waters, as the shoaler grounds have become depleted, until it is impracticable, with the present methods, to extend their operations further.

The average catch per vessel and per man is now much less than formerly; and what in the past was considered an average yield for a vessel is now an exceptionally good catch. The history of the sponge fishery during the past few years records an extraordinary number of trips that resulted in loss to the owners or equippers of sponge vessels. Furthermore, the catch now consists of a large proportion of small sponges, many being under the size sanctioned by law.

The reason for the decline of the fishery is not obscure and may be comprehended under a single head—indiscriminate fishing. Chief among the causes contributing to a decrease is the gathering of small sponges. While an excellent State law of fifteen years' standing prohibits the taking of sponges less than 4 inches in diameter across the top, the law has always been practically a dead letter. Excessive fishing has given the grounds no opportunity to recuperate from one season to another, and has made the collection of undersized sponges a necessity in order to fill out the cargoes. Almost from the beginning of the fishery there has been a total disregard for the preservation of the supply, and the present unsatisfactory conditions are the natural consequence.

Under proper restrictions there seems no reason to doubt that the Florida sponge-grounds are capable of regularly yielding a large annual catch without any danger of jeopardizing the supply. The area of the grounds is so large (estimated at over 3,000 miles) and the growth of sponges thereon is so rapid that the most ordinary precautions would probably insure a permanent crop. The remedial measures suggested for existing conditions are (1) the strict enforcement of the law as to taking small sponges, and (2) the suspension of sponging on given grounds during every second or third season. A careful survey of the productive and depleted grounds is a great desideratum, and the Commission has engaged to make such a survey as soon as practicable, employing the steamer *Fish Hawk* for the purpose.

MACKEREL INVESTIGATIONS.

Among the appendices to the present report of the Commissioner is a paper by Dr. J. Percy Moore upon the results of the investigations and experiments conducted by him for this division in the summer of 1897 relative to the embryology, natural spawning, and artificial propagation of the mackerel (*Scomber scombrus*). The investigations, which were begun in June of the last fiscal year, were conducted at Woods Hole, Massachusetts, and on board the *Fish Hawk* in Casco Bay, Maine, and were completed in the latter part of August.

These inquiries were prompted by the great scarcity of mackerel, which has now extended over a longer period than ever before in the history of the fishery, and by the large mortality among the artificially-hatched mackerel fry, to which reference has been made in earlier reports of the Commission. The supply of mackerel, as gauged by the catch, decreased markedly after 1885, and for the succeeding 13 years remained at a very low ebb, the average annual output being probably only one-seventh that of the 10 preceding years. After referring to the fact that short periods of scarcity have in the past been followed by seasons of abundance, Dr. Moore states in his report:

> Why the mackerel supply is thus subject to periodical wax and wane is unknown. There are no certain data upon which to venture a solution of the problem. Are their numbers depleted by disease? There is no evidence that the mackerel is subject to any serious infectious disease. Is the decrease due to a period of lowered fertility, of less or greater duration? Here again we lack facts. We know but little to what extent the biological and physical conditions of the sea have varied, nor yet how variations in these factors affect the vitality and habits of the mackerel. There may have been no actual diminution in the propagating capacity of the fish, but some condition peculiarly detrimental to the development of the eggs and embryos may have existed, causing their consequent destruction on a large scale. Has there been a real or only an apparent decrease due to migrations of the fish from our waters to other parts of the ocean? This view, most frequently accepted as explaining the fact, has little to support it, and is a mere guess founded on the known wandering habits of the mackerel.

The report cited first gives the results of studies relating to the spawning time of the mackerel, the development of eggs in the ovary, the characters of the ova, the process of fertilization, the vitality of the milt, the changes in the egg after fertilization, and the hatching and growth of the fry. The results of surface towings and the outcome of hatching experiments are then given, followed by a summary of conclusions and recommendations.

A point of practical importance in the artificial hatching of the fish is that during development the specific gravity of the egg gradually increases, so that, while the egg floats at the surface of the inshore waters during the early stages, it sinks to a considerable depth before hatching ensues. This fact was emphasized by the failure to obtain in surface towings any eggs in the more advanced stages of development; very few mackerel, however, were spawning in Casco Bay during the progress of the work, although the region is ordinarily one of the best spawning-grounds on our coast.

As bearing on the relatively poor results attending the artificial hatching of mackerel eggs, Dr. Moore conducted a number of experiments with different hatching methods and apparatus. These indicated that for the first two days of development no apparatus is superior to the ordinary tidal boxes, provided their sides are smooth and the screens are kept clean. Subsequently the requirements are pure water of higher density, and a hatching vessel that affords better circulation and keeps the eggs in suspension instead of permitting them to settle on the bottom among decaying organic matter.

Under the most favorable conditions it seems that the number of eggs obtainable under present methods is so insignificant, when compared with those which must be naturally hatched, that no effect on the mackerel supply is to be expected. The necessity for extensive operations suggests the possibility of securing the cooperation of the mackerel purse-seine fishermen in utilizing the eggs of the ripe fish caught by them. As is well known, the mackerel vessels frequently meet with schools of spawning fish, all of whose eggs are lost. As the artificial fertilization of mackerel eggs is very easily and quickly accomplished, and as the stripping of the fish might be carried on without interfering with the vessel's fishing operations, it is thought that the cooperation of the mackerel fishermen may be readily secured by providing each vessel with instructions as to processes, together with proper pans for mixing the spawn and milt, the eggs after fertilization being poured overboard. In this way many more eggs might be obtained from a single school of fish than would be possible in years of ordinary collecting operations.

INVESTIGATIONS OF WESTERN LAKES AND STREAMS.

WALLOWA LAKE, OREGON.

The importance of Wallowa Lake and vicinity as spawning-grounds of several species of *Salmonidæ*, and the great decrease in numbers of these fish in late years, especially of redfish, made an investigation of these waters desirable. The lake is in the extreme northwest corner of the State, at the head of Wallowa River, one of the tributaries of Snake River, the principal branch of the Columbia. Reference to a preliminary examination of this region was made in the last report of the division. In the present year the lake was visited and an extensive investigation was carried on. A party from the Commission, consisting of Dr. W. C. Kendall, in charge; Mr. Barton A. Bean, Mr. Hoffman Philip, and Mr. C. M. Rowe, reached the lake on July 13, and remained until November 14, two or three persons always being on the ground.

As was ascertained to be the case in the Idaho lakes, two forms of the redfish (*Oncorhynchus nerka*) inhabit Wallowa Lake and breed in the inlets; but the Oregon fish differ in size and other respects from the Idaho fish. The smaller fish, having a maximum length of 9½ inches, were abundant, and valuable observations on their habits were made. No important observations on the large redfish were possible, as they were almost entirely absent from these waters, only four being seen.

While the question of the migrations of the small redfish was not absolutely settled, the evidence obtained is almost conclusive that these fish have their permanent residence in the lake.

In former years a seine was operated at the head of Wallowa Lake for trout and the large redfish, considerable quantities being taken and salted annually. This fishery had to be abandoned, owing to the scarcity of fish and the enactment of a law prohibiting seining. The great diminution in the abundance of large redfish and other migratory

salmon was doubtless due to excessive fishing and the destruction of young salmon by irrigating ditches.

Other salmonoids found in these waters permanently or periodically are the chinook salmon (*Oncorhynchus tschawytscha*), which appears during the summer and early fall; the silver salmon (*O. kisutch*), known here as dog salmon, which comes in October and November; the steelhead trout (*Salmo gairdneri*), locally known as salmon trout and not always distinguished from the black-spotted trout, which appears in March and April, and is caught in the lake by trolling and gigging; the black-spotted trout (*Salmo clarkii*) and the bull trout (*Salvelinus malma*), which are permanent residents of the region; and the whitefish (*Coregonus williamsoni*), which is not uncommon, but not much fished for. Other fishes inhabiting the lake and its tributaries are lampreys, small dace, several suckers, and two or three blobs.

The most feasible method of replenishing these waters seems to be the enactment of suitable protective laws and their impartial enforcement. The remoteness of the lake from the railroad makes the introduction of fish very difficult.

BAKER LAKE, WASHINGTON.

The establishment of a hatchery for the blueback salmon or sockeye (*Oncorhynchus nerka*) at some point on the northwest coast has been under consideration by the Commission for several years. This is by far the most important species of salmon inhabiting the Puget Sound region, and the call for its artificial propagation has come chiefly from people of that section, although in the Columbia River it is taken in large quantities, ranking next to the chinook in importance.

Information having been received showing the existence of extensive spawning-grounds in Baker Lake and its tributaries, in Washington, Prof. B. W. Evermann, in August, 1898, made an examination of it with reference to its adaptability for a hatchery site.

This body of water is located in Whatcom County, in the northwestern corner of the State, near the international boundary. The nearest railroad station is Hamilton, a village on the Skagit River, 36 miles distant, whence the lake is reached by wagon road and trail, more than half the distance being a trail crossing several creeks which are at times difficult of passage; one of them, Boulder Creek, is fed by melting glaciers on Mount Baker, and for a few weeks each summer is a raging torrent in the afternoon and early evening, fording being very dangerous. The lake is about 1 mile wide and 1¼ miles long, and is little more than an expansion of Baker River, the principal northern tributary of the Skagit. It is well surrounded by high mountains, among them Mounts Baker, Shuksan, and Cleveland, on whose slopes are glaciers and large snow fields which feed the headwaters of the Skagit basin. Dense forests of cedar, spruce, hemlock, and other trees exist on all sides. Two streams, Noisy Creek and Sutter River, flow into the head of this lake, in addition to several smaller streams carrying sufficient water for hatching purposes.

In 1896 the State of Washington established a hatchery on the lake and took 6,500,000 eggs of the sockeye salmon. It is reported that many more eggs could have been secured if the facilities for handling them had warranted it. In 1897, the capacity of the hatchery having been increased to 14,000,000, the indications were that there would be no difficulty in obtaining the full quota. It seems certain that the most extensive spawning-beds of the sockeye to be found in the United States are here, and this fact, together with the excellent water-supply to be obtained by gravity, makes the lake the best-known hatchery-site for this species of salmon.

YOUNG SALMON IN THE SACRAMENTO BASIN.

The systematic studies of the movements, habits, growth, food, and enemies of young chinook salmon in the Sacramento River, referred to in the last report, were continued during this year under the charge of Mr. Cloudsley Rutter, in association with Mr. F. M. Chamberlain, who was detailed from the *Albatross*, and Mr. N. B. Scofield, who was engaged in making inquiries for the California Fish Commission.

As a preliminary measure, in order to make a general survey of the river, Mr. Rutter, in April, 1898, went by steamer from San Francisco to Redbluff, situated about 300 miles above the mouth of the Sacramento, and then extended his reconnaissance to Redding, 40 miles beyond. The river for the whole distance has a strong current and is very crooked; the lower half is comparatively narrow and deep, while the upper part is wider, with many shoals, sand-bars, and gravel-banks. Brief trials for young salmon were made near Sacramento and Redbluff; at Tehama, a few miles above Redbluff; at Battle Creek, 20 miles above, and at Redding—at each of which places, except Sacramento, salmon were abundant. On returning to the mouth of the river, salmon were found in only limited numbers, suggesting that the main body of young fish was still in the upper river.

Mr. Chamberlain was then detailed to pursue his inquiries in the lower part of the river and in the bays at its mouth, while Mr. Rutter went to the headwaters near Sisson and, in conjunction with Mr. Scofield, began a careful examination of the entire stream above Sacramento. On reaching Redbluff, May 20, on the downward trip, the further study of the river was made by means of a skiff, in which, during the following 10 days, the party rowed from Redbluff to Sacramento, a distance of 250 miles, numerous observation stations being made at suitable points.

The remainder of the fiscal year was occupied in studies adjacent to the mouth of the river. The California Fish Commission tendered the use of its steam launch, which permitted the examination of parts of San Pablo Bay that could not otherwise have been visited.

The results of the work, so far as it has been carried, are quite satisfactory and interesting. It seems that by May a large majority of the young salmon had left the smaller streams where they were hatched and had become scattered throughout the upper part of the river as far

down as Chico, about 225 miles from its mouth. Below Chico they became fewer and fewer toward Princeton, about 50 miles farther downstream, below which place they were scarce. In the latter part of May, 12 were taken in brackish water about the mouth of the river, and two weeks' work in June in the lower river and bays yielded only 5, while in the upper river from 20 to 70 were taken at each haul of a short collecting seine.

After reaching the main river the young salmon prefer to keep in the current, never being found in shallow, quiet water. A large series of specimens has been kept to show the rate of growth and the food, which will be noted in the final report. Young of the year, varying in length from 1.4 inches to 3.9 inches, have been found. The smallest—those less than 2 inches long—have been observed only in the upper river and small streams, practically none below Tehama. Those above 2 inches were about evenly distributed throughout the river.

It is thought that by the continuation of these studies for a short time sufficient information may be obtained on which to base a report giving the complete history of the quinnat salmon from the time of hatching until it runs to sea.

SOUTHERN OREGON LAKES.

Along the southern border of Oregon is a series of large isolated lakes about whose fauna nothing was known until July and August, 1897, when an examination of some of them was made by a party from the Commission, consisting of Prof. B. W. Evermann in charge, Mr. W. P. Hay, and Mr. Charles M. Rowe. The party outfitted at Ashland, Oreg., and traveled by wagon more than 600 miles. The object was to ascertain the physical and biological features of the lakes, and to make collections of the fishes and other animals found therein.

The waters examined were Goose Lake and New Pine Creek, near Lakeview; the Warner Lakes, near Plush; Abert Lake and Chewaucan River, near Paisley; Summer Lake and Summer Lake River; Silver Lake and Silver Lake Creek. These lakes are unconnected with each other, have no outlets, are quite shallow, and are more or less alkaline.

Goose Lake, the Warner Lakes, and Silver Lake are very slightly brackish and contain fish, while Abert and Summer lakes are strongly alkaline and entirely destitute of fish, although containing several kinds of small crustaceans. In Goose and Warner lakes black-speckled trout of very large size and excellent food qualities were abundant.

A study of the collections made in this region will throw much light on the characteristics of isolated fish faunas and on the origin of the faunas of these and other similar lakes in Oregon, California, and Nevada. Before a full understanding of all the questions presented is possible, it will be necessary to extend the investigations to lakes Harney and Malheur, located farther to the eastward in Oregon, and also to explore the isolated lakes in the northern part of the adjoining State of Nevada.

The Klamath Lakes, on the Oregon-California border, have already been examined by the Commission.* The relations of the faunas of these lakes to each other and to those of the Snake River Basin and the Great Salt Lake Basin present a very interesting problem in geographical distribution; and it is the purpose of the Commission to continue these investigations until a full knowledge of the fish life of these waters is obtained.

COASTAL STREAMS OF WASHINGTON, OREGON, AND CALIFORNIA.

In the summer and fall of 1898 a systematic examination of the salmon streams of the coast of Washington was taken up. Mr. Cloudsley Rutter was in charge of the investigations, and was assisted at times by Mr. C. F. Foote and Mr. E. R. Brady. The inquiry was begun about July 25, immediately north of the Columbia River, and was concluded on October 1, by which time the streams on the south side of the Strait of Fuca were reached.

The investigations had for their object the determination of the physical character of the principal streams, the nature of the general fish fauna, and the distribution, abundance, habits, spawning, etc., of the different species of salmon.

Among the numerous waters visited were the following: Nasel, Willapa, and North rivers, tributary to Willapa Bay; Chehalis River, which empties into Grays Harbor, with its more important branches, including Black River and Black Lake, Satsop River, Wynooche River, the east and west forks of Wishkab River, and a number of smaller streams; east and west forks of Humptulips River, which enters Grays Harbor; Lake Quinault and its tributaries; Elk Creek, a branch of Quinault River; Raft River; Queets River with its tributaries, Salmon River, Tacoma Creek, Mud Creek, Clearwater River, and Hurst Creek; Hoh or Ohalot River; Bogachiel River, tributary of the Quillayute River; Ozette Lake and tributaries; Pleasant Lake, Beaver Lake, Beaver Creek, and Soleduc River, in the Quillayute Basin; Crescent Lake and Sutherland Lake, with their feeders and outlets.

Many of the foregoing waters are very remote from regular lines of communication and had never before been examined with reference to their fish life. Large collections of the fishes and other water animals were made for future study.

The investigation showed that both the quinnat salmon and the silver salmon are found in all the principal streams, and that the dog salmon is distributed throughout the region and ascends even the smallest streams. The blueback salmon, or redfish, enters the Quinault River and Lake, and also Ozette Lake. The dwarfed redfish exists in Ozette Lake, and probably in Quinault Lake. Ozette Lake affords good facilities for a conclusive study of the question as to whether the small redfish are migratory or permanent residents of lakes.

*The Fishes of the Klamath Basin. By Charles H. Gilbert. Bull. U. S. Fish Commission, 1897.

The examination of the coast streams of California begun in May, 1897, and referred to in the last annual report, was continued until August 15, 1897, by which time all the rivers of California north of San Francisco and some of those of southern Oregon had been visited. The inquiries were in charge of Dr. C. H. Gilbert, of Leland Stanford Junior University, assisted by four students of that institution. The streams were very thoroughly examined with reference to their fish life, large collections of fish, crustaceans, mollusks, etc., being made.

OTHER INVESTIGATIONS.

SHAD OF THE OHIO RIVER BASIN.

From time to time the capture of shad in the Ohio and Mississippi rivers and their tributaries has been reported. The fish have locally been regarded as identical with the shad of the Atlantic coast (*Alosa sapidissima*), and have been called "Potomac shad," "white shad," etc. In view of the large numbers of shad fry planted in the Mississippi Valley, it has been thought that their attempted acclimatization may have proved successful. Ichthyologists have had little opportunity to examine these shad from the Ohio basin, but the Commission has recently been able to make some interesting observations thereon. In the spring of 1896 it was reported from Montgomery, W. Va., that shad were being taken in some numbers in the Kanawha River at that place. In May, 1897, a fish-dealer in Louisville, Ky., stated that considerable quantities of shad were being caught at the Falls of the Ohio, and four fresh specimens were sent for identification. The same dealer, in May, 1898, wrote that the shad had again appeared, and forwarded six specimens. An examination showed that these represented a species of true shad (*Alosa*), and not a hickory shad or skipjack (*Pomolobus*), gizzard shad (*Dorosoma*), or mooneye (*Hiodon*), which are popularly known as shad in various parts of the interior. It was also seen that they were closely related to the shad of the rivers of the Atlantic slope, but had certain characters which were apparently sufficiently marked to render the fish specifically distinct from the common shad, and also from the shad (*Alosa alabamæ*) recently described from the Black Warrior River, Alabama.

In order to secure more definite information regarding the nature, movements, and abundance of this fish, Prof. B. W. Evermann, in May, 1898, was instructed to proceed to suitable points on the Ohio River and tributaries.

Montgomery, W. Va., was first visited. No shad had yet arrived, but additional information concerning the runs in 1896 and 1897 was obtained. In 1896 the fish appeared during the third week in May, the largest number being caught on May 20. Several hundreds were taken for home use by the people of the town, and the run was reported to consist of thousands of fish. In the following year the shad came about the same time and were reported to be quite as numerous.

When Louisville was visited, May 16–19, the shad were running and good opportunities were afforded for studying them. They were being caught in seines at the Falls of the Ohio, chiefly on the Indiana side, together with spoonbill catfish, shovel-nose sturgeon, and drum. It is said that the shad from the Ohio first came under the observation of the Louisville dealers in about 1876; the fish were at once identified as "Potomac shad" by those dealers familiar with the shad of the Atlantic coast. A good many were caught at the Falls of the Ohio that year and met with a ready sale. A few were taken in some of the succeeding years, but no large catch occurred until 1897, when a change in the method of rigging the seines may have had some effect on the number taken. In 1897 the run was large, and several thousand were secured, the daily catch during the first three weeks in May being from about 125 to 740. In 1898 the first shad was caught April 28; from that time the number increased until about May 17, when the run began to decline. The total yield in 1898 was about the same as in 1897.

This species of shad has not, so far as known, been taken in large numbers, except at Louisville, but it has been reported from various places on the Mississippi, and at a number of places below Louisville on the Ohio and Mississippi rivers. In March, 1898, a Louisville fish-dealer saw 25 or 30 captured at Cahoma, Miss., where the fishermen stated that a good many were taken, and thought they were a species of skipjack. The same dealer has seen the shad in the Ohio River at Concordia, Ky., 90 miles below Louisville, and at Brandenberg, Ky., 40 miles below Louisville. About fifteen years ago they were reported at Vicksburg, Miss., in 1884 at Hickman, Ky., and in 1886 and since at Aurora, Ind. A fish-dealer at Evansville, Ind., reports that some years ago he caught shad in the Wabash River near its mouth, and that about twenty years ago, and also in 1897, he saw a few that had been taken in the Ohio River.

None of the dealers at Vincennes has ever seen any shad from the Ohio or the Wabash, but one states that in the spring of 1898 he received a few from St. Louis. None of the dealers and fishermen interviewed at Terre Haute had ever seen shad from the Wabash River. That shad have not been taken in this stream may be due to the legal restrictions on all methods of fishing which would be likely to result in the capture of such a fish.

STUDIES OF YOUNG SHAD IN POTOMAC RIVER.

The studies of young shad in the Potomac River, referred to in the previous report, were continued throughout the fiscal year 1897–98. The inquiries, which were in charge of Mr. M. C. Marsh, related mainly to the movements, food, and rate of growth. While much has been definitely established, further inquiries will be necessary before the full history of the young shad is known.

The observations have shown that shad hatched in the spring of one year are abundant during the ensuing summer months throughout the fresh portion of the river below Little Falls. They feed in the shore

waters all summer, with practically no downward migration. At this season, also, near the surface in the open water of the river, they seem to be present in moderate numbers and are perhaps abundant, but the means available for collecting in the offshore waters have not been satisfactory. With the approach of cold weather the young shad do not descend the river along the shores in order to reach warmer water, but withdraw to the river channel. When the temperature of the water falls to a point between 46° and 56°, which happens in November, they leave the places they have frequented during the summer. This movement is perfectly well marked throughout the section above brackish water. Observations in winter and spring indicate that there is some downward movement after the fish leave the shores, and this must necessarily take place in the deeper water. Seining in the Lower Potomac and along the western shore of Chesapeake Bay in the latter half of February showed that no young shad were there, but about the end of March numbers were noticed in the pound nets set along the shores of the Lower Chesapeake near Old Point Comfort and the Virginia capes. These were the previous spring's hatch, and such fish have also been noted in the Lower Potomac. Shad of apparently two years' growth have been taken in both the bay and lower river, but the young do not reappear on the shores in spring in the fresh water of the river.

It seems probable that at least some of the young shad of a particular season's spawning do not reach the ocean during the ensuing year, and it is possible that some reach maturity (in three or four years) without visiting the ocean. Deep-water collecting in Chesapeake Bay in midwinter will do much to fill the present hiatus in our knowledge of the shad during that season.

Insects and entomostracans are the most important food of the young shad in fresh water. Of entomostracans, the genera *Daphnia*, *Cyclops*, *Cypris*, and *Bosmina* are largely represented in the stomach contents. Rhizopods, nematodes, amphipods and gastropods are eaten; vegetable food is rarely taken. In a few cases small fish had been ingested and shad fry have been found in the stomach, but this is unusual.

When 2 months old, shad are about 2 inches long; having attained this size, they add about an inch to their length in from 2½ to 3½ months, so that when they leave the fresh water in the fall they are from 3½ to 4 inches long. They grow slower in the river than in ponds (such as the Government fish-ponds at Washington). Fish from the upper part of the river are distinctly smaller than those from the lower, having been hatched later.

FISHES AND FISHING-GROUNDS OFF SAN DIEGO COUNTY, CALIFORNIA.

In March and April, 1898, Messrs. C. Rutter and F. M. Chamberlain were assigned to an examination of the fishery resources and fishing-grounds of the southern California coast. The steamer *Albatross*, which was then lying off San Diego, was made the headquarters of these assistants while working in the vicinity. It was the intention to have

shore inquiries conducted in conjunction with the dredging, collecting, and hydrographic work on the vessel, but the *Albatross* was transferred to the Navy Department shortly after the investigations were begun, and the only studies made were those relating to the fish, fishing, and fishing-grounds of San Diego County. The recent marked development of the fishing industry of the southern counties of California makes it very desirable that a thorough examination of the outlying fishing-grounds should be carried on with reference to the habits, migrations, abundance, food, spawning, etc., of the fishes found thereon. This work should be taken up by the *Albatross* as soon as practicable.

The barracuda (*Sphyræna argentea*) is by far the most important food-fish taken in this section. It makes its appearance in February or March and remains until November, rarely until December, being most abundant from April to August. It is found off the shores of Lower California in January, which leads the fishermen to believe that it travels northward along the coast; but the fact that in one season recently the barracuda was caught at San Pedro, Los Angeles County, a few weeks earlier than at San Diego, would indicate that its movements toward the coast are chiefly from deep water offshore.

Other important fishes of the San Diego region are bonito (*Sarda chilensis*), yellow-tail (*Seriola dorsalis*), several species of bass (*Paralabrax*), flounder (*Paralichthys californicus*), and rockfishes (*Sebastodes*) of many species.

EXPERIMENTS WITH SALMON OVA.

In October and November, 1897, during the prosecution of salmon-hatching work at Battle Creek Station, Cal., Mr. Cloudsley Rutter, scientific assistant, conducted some experiments having a practical bearing on fish-cultural work, and chiefly directed to questions relating to the fertilization and development of the eggs of the quinnat salmon (*Oncorhynchus tschawytscha*). Among the subjects specially considered were the influence on fertilization of the exposure of the eggs to water, the vitality of the milt, the fertilizing of eggs from dead fish, the fertilization of bloody, slimy, and foamy eggs, the effects of handling eggs at supposed critical periods, and the percentage of eggs fertilized under natural and artificial conditions. The studies were not completed and they will probably be resumed next season. An outline of the general results is here given.

Numerous experiments were tried to determine how long salmon eggs might remain in water and still be capable of fertilization. This subject has a very important bearing on fish-cultural operations as well as on natural reproduction. No eggs were fertilizable after they had been in water more than 5 minutes, and only 2 per cent on 5 minutes' immersion. After being in water $2\frac{1}{2}$ minutes, 16 per cent were fertilized. After rapidly washing the blood from eggs taken from fish already stripped, only 11 per cent were fertilized.

Spermatozoa were found to live for more than 10 minutes after the milt was mixed with water, but their fertilizing powers rapidly dete-

riorate. Thus, the experiments showed that after milt had been in water 1 minute it fertilized 19 per cent of the eggs treated; after a lapse of 3½ minutes, only 9 per cent were fertilized; after 6 minutes, 8 per cent; after 8½ minutes, 2 per cent; and after 11 minutes, 2 per cent, no fertilization occurring after a longer interval.

It occasionally happens that a fish is injured before spawning, and when the eggs are pressed out they are mixed with more or less blood. Eggs from three such fishes were selected, in order to ascertain the percentage of fertilization. About 8 per cent of them died within 5 days, and of the remainder, 2 per cent were unfertilized. This is not very different from the average results under normal conditions. Of several lots of bloody eggs taken from stripped fish, 89 per cent were fertilized. In the passage of eggs through the oviduct the natural liquids of the part often become foamy. It was not known whether such eggs were fertilizable, but tests showed that this condition did not impair the susceptibility of the egg to the action of the milt. The slime from fishes is thought by some fish-culturists to be fatal to spermatozoa; some eggs were thoroughly mixed with slime and then treated with milt in the usual way; less than 2 per cent were unfertilized.

The question of killing the female salmon before attempting to take the eggs received some consideration. Stripping the female is very hard work, requiring the services of three men, one to hold the head and one the tail, while the third expresses the eggs. Even when the fish is ripe, a man's entire strength is often required to force the eggs through the oviduct. Many good eggs are necessarily left in the fish and thus lost. In 21 stripped salmon examined with this point in view, there were found on an average 700 ripe eggs, or about 14 per cent of the total average production per fish. It had been claimed by some fish-culturists that eggs from fish killed before spawning would produce deformed fry, but this was shown by experiments to be erroneous. In view of the foregoing experiments and the additional fact that these fish die after spawning, there would seem to be good reasons for killing or stunning them by a blow on the head and for removing the eggs through an artificial opening in the abdominal wall.

It is well known that at certain ages eggs are much more delicate than at other times. These critical periods are when the eye-spots first appear (ninth to fifteenth day) and just before hatching. When first taken, eggs may be handled comparatively roughly with impunity. The spawning-place at Battle Creek is 1½ miles from the hatchery, the eggs being hauled that distance in wagons over a rather uneven road without any injury. Nearly 700,000 eggs 43 days old were sent from Battle Creek to Olema; they were first taken 10 miles in a heavy wagon, and were then carried on a railroad train 15 hours, being out of the water 48 hours; the loss in transit was only 300 eggs. At other times such treatment would kill almost every egg, the simple turning of the eggs with a feather often causing a large loss. In one experiment 120,000

eggs, in four equal lots, were employed to demonstrate the critical periods; two lots were picked daily to remove dead eggs; the other two lots were picked only on the first, third, twenty-second, twenty-fourth, and forty-first days, so as to avoid the critical times. The percentages of loss in the first two lots were 56 and 32, respectively, and in the second two 11 and 9, respectively.

A number of tests indicated that even after a fish has been dead in the water for a comparatively long time the contained eggs remain in good condition. On November 25 a female salmon that had died below the spawning rack was selected for experimentation. Eggs were taken and fertilized at periods of 2, 4, 6, 8, and 24 hours after its death. In the case of the first four lots the percentages fertilized were 99, 98, 92, and 92, respectively, and at the end of 26 days the eggs were healthy. The eggs taken after a lapse of 24 hours were not sound, and although most of them were fertilized, the entire lot died within 2 weeks. On the 13th of November eggs were obtained from 2 fish that had died in the water, one having been dead 2 hours and the other over 6 hours; of the former, 97 per cent and of the latter 85 per cent hatched and produced healthy fry.

LAKE SUPERIOR.

The investigations of Mr. A. J. Woolman in Lake Superior begun in April, 1897, and referred to in the last report, were continued until the latter part of August, 1897. They had for their object the determination of the food-supply of the fishes of the lake and its relation to the abundance and movements of the commercial fishes. Large collections of the minute animal life, which directly or indirectly constitutes the principal food of the fishes, were made with fine-meshed nets used at the surface, bottom, and intermediate depths on the fishing-grounds along the south shore. The study of the collections has not yet been completed.

Different regions were found to differ very materially in the variety of small aquatic animal forms inhabiting them and in the abundance of those forms. Some extensive areas were shown to be abundantly supplied with minute animals in great variety, which in other areas were almost completely absent. If further observations show that the distribution of the minute animals is in any way constant in given areas, information of value in the planting of fish fry will have been obtained.

One noteworthy feature of the inquiries was the discovery of small crustaceans (*Diaptomus*) in large numbers in certain very deep waters where there has recently been a remarkable increase in the abundance of the bluefin whitefish (*Argyrosomus nigripinnis*).* These crustaceans occur in large quantities only in deep water (100 to 130 fathoms), where they are the predominating animals of this class. Another observation was that apparently well-defined areas are occupied by cladocera, as

* See Report U. S. Fish Commission for 1897, pp. CXXI, CXXII.

distinct from regions occupied by certain copepoda and the still more localized areas inhabited by ostracoda.

FISH PATHOLOGY.

Assistants of the division have made a number of examinations of fishes that have died at various stations of the Commission, but usually the results of the studies have been unsatisfactory. Lesions have sometimes been found which would result in death, but the causes of the morbid processes or conditions have not been apparent. In other cases no clew to the disease has been detected.

One of the most important subjects now connected with fish-culture is fish pathology. With the exception of the effects produced by a few animal and vegetable parasites, practically nothing is known of the diseases of fishes. This is a very inviting field for study from the scientific standpoint and from the practical standpoint of fish-culture. A very large mortality not infrequently prevails among young and mature fish at hatching stations, in stocked waters, and among wild fish, for which there is no known cause or remedy. The annual unavoidable losses in the Commission, while not excessive, are yet sufficiently serious to demonstrate the necessity, which has long been appreciated, for an assistant who could devote his whole time to the consideration of fish diseases, and who is fitted by previous training in human pathology to fully comprehend the nature, cause, and possible remedies for the now obscure affections prevailing among the food and game fishes. It is strongly urged that the Commission be provided with a permanent expert in fish pathology.

WOODS HOLE, MASSACHUSETTS.

WORK IN THE LABORATORY.

During the summer of 1897 the Woods Hole laboratory was occupied by a small number of investigators, the Commission having restricted the attendance to representatives of those institutions which had furnished financial aid in the construction and equipment of the laboratory. Among those at the station were Dr. John Y. Graham, of the University of Alabama, and formerly of Princeton University; Mr. F. N. Balch, of Harvard University; Mr. Charles W. Greene, of Johns Hopkins University; Dr. J. Percy Moore, of the University of Pennsylvania, who was engaged in studies on the embryology of the mackerel in the interest of the Commission. At the request of the Smithsonian Institution, Prof. C. C. Nutting, of the University of Iowa, was granted laboratory privileges to enable him to complete his work on American hydroids for the institution.

In the spring of 1898 it was determined to take steps to increase the opportunities for scientific study at Woods Hole, by providing for the prosecution of inquiries throughout the year instead of only during the summer months, as heretofore. It was also decided to place the laboratory in the charge of some competent biologist, who would be in

attendance during most of the year and give personal direction to the investigations. The laboratory was opened on March 14, and Dr. H. C. Bumpus, professor of comparative anatomy in Brown University, was appointed director. Correspondence was entered into with the principal universities and colleges, notifying them of the opening of the laboratory and stating that nominations of a limited number of persons to represent them would be received. During April fourteen investigators availed themselves of the privileges of the laboratory, and by the 1st of June accommodations for the ensuing summer had been assigned to the full capacity of the station.

During a period of six weeks in May and June the work of the laboratory was facilitated by the courteous action of the trustees of the Marine Biological Laboratory in placing their steam launch at the disposal of the Commission.

Reports on the aquatic life present in the vicinity of the station during March, April, and May were published in the current issues of "Science," by Dr. Bumpus and Dr. A. D. Mead, for the guidance of those who may desire to pursue studies at the laboratory in the spring months. In an article on "The breeding of animals at Woods Hole during the month of March, 1898," Dr. Bumpus stated:

> The water has swarmed with animal life, and many forms rarely or never captured during the warmer months have been found in abundance. Breeding animals have yielded rare embryological material, and all forms of life have had great vitality, due probably to the low temperature of the water (38° to 43° F.).

MORTALITY AMONG BROOD COD AT WOODS HOLE.

During the cod-hatching season of 1897–98 at Woods Hole there was a very large death rate among the adult cod retained in live-cars. In previous seasons numbers of the brood cod had died, but the mortality during the present year was greater than heretofore. These fish were caught with hand-lines on Nantucket Shoals and brought to the station in welled-smacks. Between October and February 3,507 were received, of which 2,696 died, or more than 76 per cent; 1,977 dying in November, 315 in December, 203 in October, 143 in February, and 58 in January.

In November 14 cod, each weighing 5 or 6 pounds, that had died in the live-cars, were sent to Washington in ice and there carefully examined. In 11 cases there was no doubt of the cause of death, in 2 the cause was not positively made out, and in 1 it could not be determined. Cerebral meningitis, due to hook wounds, was responsible for the death of 5 fish; the same condition, resulting from injuries to the eye, led to the death of 2 others; cerebro-spinal meningitis, induced by a blow on the side, caused the death of 1 fish; marked degeneration of the heart muscle was found in two cases, and inflammation of the heart or pericardium existed in 2 fish, being complicated with meningitis, due to hook wound in one of them. In one of the doubtful cases there was slight meningitis traceable to a hook wound, and in the other there seemed to be a rupture of the abdominal aorta.

The inflammation resulting from the hook wounds could easily be traced to the membranes of the brain, which were in most instances highly congested and surrounded by considerable bloody serum. While such injuries are often unavoidable, it is probable that some might have been less severe had more care been exercised in extracting the hooks. In the cases of meningitis due to injuries to the eyes, there is ground for suspicion of rough handling. Fishermen have a practice of thrusting the forefinger and thumb into the eyes of cod and other fish in order to secure a firm hold in removing the hook, and in this way displacement of the lens, rupture of the eyeball, and other injuries may result. The cases of degeneration and inflammation of the cardiac muscle and of rupture of the aorta might be occasioned by heavy pressure on the ventral region between the gills. Fishermen, while removing the hook, often grasp fish in the place stated, squeezing the heart and related structures with sufficient force to produce serious lesions. The fish whose death depended on cerebro-spinal meningitis was clearly the victim of rough handling; the wound in the side was such as might be produced by a swinging blow on the thwarts or gunwale of a boat.

Subsequent examinations of many cod at the station showed conditions similar to those mentioned. There seems no reason to believe that the fish received rougher treatment this season than formerly. The high mortality may have depended on special physical surroundings, such as high-water temperature, which promoted inflammation, perhaps septic, that under other conditions would not have ensued. The experience, however, demonstrates the necessity for great care in handling cod that are to be kept in confinement for several months.

TAGGING COD AT WOODS HOLE.

During December, January and February 560 cod, weighing from 3 to 17 pounds, were tagged at Woods Hole and released in adjacent waters. These fish had been caught with hand-lines on the southern Massachusetts coast and retained at Woods Hole for brood purposes. After their use in the fish-cultural work, they were liberated with a small tin or copper tag attached to one fin by silver or copper wire. Complete data were kept for each fish tagged, including its weight, length, sex, and when and where released. A printed circular calling attention to the experiment and soliciting certain information regarding the fish was extensively circulated in the coast towns of Massachusetts, Rhode Island, and Connecticut, and also in New York and New Jersey. Within a few weeks after the fish were released tagged fish began to be caught, and by the close of the fiscal year about 25 tags had been received, while the taking of other fish was reported; these were mostly from southern Massachusetts, but some came from Rhode Island, Connecticut, and New York, and one from a point on the middle New Jersey coast. It is expected that the experiment may throw some light on the rate of growth of the cod, the frequency of its spawning, the extent to which individual fish migrate, etc.

COLLECTIONS AND REPORTS.

A small collection of fishes obtained by the *Albatross* on the coast of southern California in April, 1897, was transferred to Dr. Charles H. Gilbert, of Stanford University, for examination and report. The collecting was done in the neighborhood of Santa Catalina Island and Monterey Bay, with dredge, gill net, trawl line, hand line, and shore seine. The greatest depth at which trials for fish were made was 581 fathoms off Monterey Bay with gill net and beam-trawl; another trial with these appliances in the same region was in 278 fathoms; all the other collecting was in water less than 100 fathoms deep. Dr. Gilbert's report, which appears in the appendix to this report (pp. 23–29), shows that 62 species of fish were secured, one-third of which are rockfishes (*Scorpænidæ*), while most of the others are the common shore species. Off Santa Catalina Island, at depths of 47 fathoms and 80 fathoms, respectively, two undescribed species were obtained, one an agonoid (*Averruncus sterletus*), the other a cottoid (*Radulinus boleoides*).

The interest of late manifested in the fish and fisheries of Florida has suggested the need of a comprehensive report on the fish fauna of that State. The preparation of such a report has been begun by Drs. Evermann and Kendall, based on extensive collections made by the Commission, and on previously published lists of Florida fishes. About 600 species are now known from Florida waters, and the fish fauna is consequently more varied than that of any other State. Some additional field investigations in certain sections are desirable; these will doubtless considerably augment the list.

In conformity with the established custom, natural-history objects obtained by the field parties and vessels of the Commission have been transferred to the United States National Museum. The large collections of aquatic animals sent to the Museum during the year included reptiles, batrachians, mollusks, crustaceans, and other invertebrates, besides rare fishes and types. These collections are studied and reported on by specialists connected with the National Museum and Smithsonian Institution.

Arrangements have been made to supply to the leading educational institutions of the country sets of named marine and fresh-water fishes in alcohol. After collections have been reported on, and complete series of specimens have been reserved for the Government, the best use to which they can be put is to donate them to universities, colleges, and schools having biological courses, and to State museums.

The various papers pertaining to the functions of this division which have appeared during the year have been mentioned in the foregoing report of the Commissioner.

REPORT OF THE DIVISION OF STATISTICS AND METHODS OF THE FISHERIES.

By C. H. Townsend, *Assistant in Charge.*

The work of this division for the year ending June 30, 1897, was reported upon by Dr. Hugh M. Smith, whom the writer succeeded as assistant in charge on April 7, 1897, having been detached as naturalist of the steamer *Albatross*. By direction of the Commissioner a canvass of the principal fisheries of certain New England and Middle Atlantic States and the Great Lakes for the fiscal year 1897 was commenced on August 1. The statistical field agents of the division were detailed as follows: To Maine and New Hampshire, Mr. Ansley Hall; to Massachusetts, Mr. W. A. Wilcox; to New York, New Jersey, and Delaware, Mr. C. H. Stevenson; to Lake Superior, Mr. T. M. Cogswell; to Lakes Michigan, Huron, St. Clair, and Erie, Mr. H. O. Weaver; to Lake Ontario, Mr. John N. Cobb. The fisheries of Lake Ontario were canvassed in full, the data collected relating to the calendar year 1897.

With a view to securing information for the use of the National Fishery Congress at Tampa, in January, 1898, Mr. Cobb was sent to Florida in September and October to canvass the fisheries. The results of the fieldwork conducted in the above-mentioned regions were at once made public in a series of single sheet bulletins, each of which was distributed throughout the region to which it referred. The bulletins were sent to post-offices, custom-houses, commercial organizations, fishing firms, fishermen, and representative newspapers. The conditions of the fishery industries were thus presented in condensed form in advance of the regular report of the Commissioner. It is proposed to continue, from time to time, the issuing of such bulletins respecting the commercial fisheries whenever the information obtained proves of special interest. The titles of bulletins which have already appeared are as follows:

Sponge Fisheries of Florida.
Statistics of Certain Fisheries of Lake Superior.
Statistics of Certain Fisheries of Florida.
Statistics of Certain Fisheries of New York, New Jersey, and Delaware.
Statistics of Certain Fisheries of Maine, New Hampshire, and Massachusetts.
Statistics of Certain Fisheries of The Great Lakes.

The information collected regularly by local agents of the division, respecting the important fisheries of Boston and Gloucester, has, since August, 1897, been presented monthly in the form of single sheet bulletins and distributed to persons directly engaged in those fisheries. These bulletins are also posted in public buildings, while several trade journals give them further circulation in their columns.

Mr. W. A. Roberts, field agent, was employed at Nashville during the Tennessee Centennial Exposition, in connection with the Fish Commission exhibit. In November the writer was detailed there by the Commissioner for a short time to take charge of the exhibit, and in January was detailed as a delegate to the Tampa Fishery Congress.

During the spring of 1898 a canvass was made of all the fisheries of the South Atlantic and Gulf States, Messrs. Stevenson, Wilcox, Hall, Cobb, and Cogswell engaging in the field inquiries. Upon the completion of this work the canvass was extended into the Middle Atlantic States, and continued during the summer, with the assistance of Messrs. W. A. Roberts and E. S. King.

During the year an office was established at San Francisco as headquarters for the Commission on the Pacific coast and especially to make available for general shore work the civilian force connected with the steamer *Albatross*. It has proved very useful during the recent transfer of the vessel to the Navy Department, Mr. A. B. Alexander, F. M. Chamberlain, and C. Rutter having been ordered there to conduct inquiries respecting the important fisheries of that locality. As the vessel is periodically laid up for repairs or during seasons unfavorable for sea work, the local office at once becomes a point from which men may be distributed for statistical, fish-cultural, or scientific work.

The statistical work at San Francisco will, when finished, show the condition of the commercial fisheries from month to month during the year, both as to the quantity and value of the different food species on which the market depends. The seasonal supply of shad and striped bass, which have been introduced on the Pacific coast by the Fish Commission and are now abundant, is especially interesting in this connection.

FISHERIES OF GLOUCESTER AND BOSTON.

The reports of the agents of the Commission, located at Gloucester and Boston, Mass., show that there has been a slight decrease in the fisheries of those places since 1896. The fish landed by American vessels amounted to 126,865,598 pounds, having a first value of $2,878,635. The total number of fares was 6,476. Compared with 1896 the figures for 1897 show a decrease of 3,808,168 pounds, and a decrease in value of $408,263. The fish landed at Gloucester amounted to 63,962,040 pounds, of which 32,960,261 pounds were fresh, and 31,001,779 pounds were salted. The total value was $1,648,591. The increase in the fresh fish landed at Gloucester since 1896 amounted to 11,035,560 pounds. A decrease is shown in the total catch for Gloucester of 3,635,374 pounds. There were 2,391 fares landed at Gloucester, of which 1,688 were from grounds off the New England coast, and 703 from the eastern banks and the Gulf of St. Lawrence. There is an increase in the number of fares since 1896 of 171.

In December, 1897, the facilities for handling and shipping fresh fish at Gloucester were largely increased, with the result that many vessels now land their entire catch of fresh fish at that port. This result was

brought about by a desire on the part of the owners of Gloucester vessels to keep them more directly under their own supervision, to make Gloucester more important as a shipping point for fresh fish, and to increase the general volume of trade at that point. This arrangement, diverting a portion of the catch of fresh fish from Boston, where it had previously been landed, has created a spirit of rivalry between the fishery interests of the two places.

The following tables show the receipts from each ground:

Summary by fishing-grounds of certain fishery products landed at Gloucester, Mass., in 1897 by American fishing vessels.

Fishing-grounds.	No. of trips.	Cod.				Cusk.			
		Fresh.		Salted.		Fresh.		Salted.	
		Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
East of 66° W. longitude:									
La Have Bank	193	1,979,040	$36,046	1,480,463	$42,929	814,500	$9,656	4,000	$100
Western Bank	38	693,520	10,879	420,478	13,291	32,000	393	3,600	81
Quereau Bank	96	18,000	260	169,500	5,825				
Green Bank	14			18,000	560				
Grand Bank	107			11,946,154	253,091				
Canso Bank	6			418,435	9,890				
St. Peters Bank	5								
Burgeo Bank	23			10,000	208				
Bacalieu Bank	84								
Off Newfoundland	58								
Cape Shore	52	50,000	750	5,000	125			5,000	113
Gulf of St. Lawrence	27								
Total	703	2,740,560	47,935	14,468,030	325,919	846,500	10,049	12,600	294
West of 66° W. longitude:									
Browns Bank	47	397,159	4,843	382,696	10,382	132,000	1,400	17,000	380
Georges Bank	641	1,386,695	17,863	9,345,260	262,420	54,140	734	109,350	2,372
Cashes Bank	109	364,880	5,028	10,000	325	614,970	6,633		
Jeffreys Ledge	40	131,200	2,970			74,120	855		
Ipswich Bay	2	1,500	17						
South Channel	56	324,400	6,548			65,800	720		
Nantucket Shoals	20			551,053	12,388				
Shore, general	773	662,332	13,839			62,600	761	5,000	113
Total	1,688	3,268,166	51,108	10,289,009	285,515	1,003,630	11,103	131,350	2,865
Grand total	2,391	6,008,726	99,043	24,757,039	611,434	1,850,130	21,152	143,950	3,159

Fishing-grounds.	Haddock.		Hake.				Pollock.	
	Fresh.		Fresh.		Salted.		Fresh.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
East of 66° W. longitude:								
La Have Bank	742,000	$12,052	4,217,300	$33,588				
Western Bank	57,000	1,026	182,000	1,439				
Quereau Bank	50,000	200						
Cape Shore							30,000	$280
Total	849,000	13,278	4,399,300	35,027			30,000	280
West of 66° W. longitude:								
Browns Bank	147,000	635	141,000	979	8,000	$57	800	4
Georges Bank	1,705,500	9,453	31,000	198				
Cashes Bank	59,000	771	1,972,400	14,189				
Jeffreys Ledge	136,550	3,115	161,700	1,291				
South Channel	325,600	7,152	167,100	1,332				
Shore, general	140,223	3,004	1,216,300	10,254	10,000	125	918,155	5,673
Total	2,513,873	24,130	3,689,500	28,243	18,000	182	918,955	5,677
Grand total	3,362,873	37,408	8,088,800	63,270	18,000	182	948,955	5,957

Summary by fishing-grounds of certain fishery products landed at Gloucester, Mass., in 1897 by American vessels—Continued.

Fishing-grounds.	Halibut.				Mackerel.			
	Fresh.		Salted.		Fresh.		Salted.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
East of 66° W. longitude:								
La Have Bank	84,488	$7,251						
Western Bank	217,835	15,750	2,000	$90				
Quereau Bank	1,722,209	150,032						
Green Bank	300,244	21,535						
Grand Bank	955,188	65,392	7,440	340				
Canso Bank	7,000	370						
St. Peters Bank	155,578	7,600						
Burgeo Bank	347,577	28,944	8,000	400				
Bacalieu Bank	2,598,169	136,669	1,449,000	56,849				
Off Newfoundland	44,465	3,984						
Cape Shore	8,128	425			500	$45	420,800	$21,182
Gulf of St. Lawrence							332,400	36,618
Total	6,440,881	437,952	1,466,440	57,679	500	45	753,200	57,800
West of 66° W. longitude:								
Browns Bank	39,239	2,992						
Georges Bank	802,253	61,758			124,240	7,773	456,600	34,935
Cashes Bank	1,715	206					7,000	385
Ipswich Bay					2,500	200		
South Channel	800	86			30,780	1,710	58,000	3,190
Nantucket Shoals	1,400.	70						
Shore, general					99,634	7,216	434,300	33,036
Total	845,407	65,112			257,154	16,899	955,900	71,546
Grand total	7,286,288	503,064	1,466,440	57,679	257,654	16,944	1,709,100	129,346

Fishing-grounds.	Other fish.				Total.			
	Fresh.		Salted.		Fresh.		Salted.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
East of 66° W. longitude:								
La Have Bank					7,837,328	$98,593	1,484,463	$43,029
Western Bank					1,182,355	29,487	426,078	13,462
Quereau Bank					1,790,209	150,492	169,500	5,825
Green Bank					300,244	21,535	18,000	560
Grand Bank					955,188	65,392	11,953,594	253,431
Canso Bank					7,000	370	418,435	9,890
St. Peters Bank					155,578	7,600		
Burgeo Bank					347,577	28,944	18,000	608
Bacalieu Bank					2,598,169	136,669	1,449,000	56,849
Off Newfoundland	5,141,800	$57,790	2,526,250	$35,100	5,186,265	61,774	2,526,250	35,100
Cape Shore					88,628	1,500	430,800	21,420
Gulf of St. Lawrence							332,400	36,618
Total	5,141,800	57,790	2,526,250	35,100	20,448,541	602,356	19,226,520	476,792
West of 66° W. longitude:								
Browns Bank					857,198	10,853	407,696	10,819
Georges Bank					4,103,828	97,779	9,911,210	299,727
Cashes Bank					3,012,965	26,827	17,000	710
Jeffreys Ledge					503,570	8,231		
Ipswich Bay					4,000	217		
South Channel					914,480	17,548	58,000	3,190
Nantucket Shoals					1,400	70	551,053	12,388
Shore, general	15,035	808	381,000	6,255	3,114,279	41,555	830,300	39,529
Total	15,035	808	381,000	6,255	12,511,720	203,080	11,775,259	366,363
Grand total	5,156,835	58,598	2,907,250	41,355	32,960,261	805,436	31,001,779	843,155

The fishery products landed at Boston by American vessels in 1897 amounted to 62,903,558 pounds, valued at $1,230,014. There has been a decrease since 1896 of 172,794 pounds, worth $54,950. 4,085 fares in all were landed, or 102 less than in the previous year; 3,874 fares were from grounds off the New England coast.

Summary by fishing-grounds of certain fishery products landed at Boston, Mass., in 1897 by American fishing vessels.

Fishing-grounds.	No. of trips.	Cod. Fresh. Pounds.	Cod. Fresh. Value.	Cusk. Fresh. Pounds.	Cusk. Fresh. Value.	Haddock. Fresh. Pounds.	Haddock. Fresh. Value.
East of 66° W. longitude:							
La Have Bank	102	923,000	$21,969	172,000	$1,924	1,152,300	$20,064
Western Bank	48	401,500	7,588	139,500	1,352	122,200	1,906
Grand Bank	1						
Off Newfoundland	15						
Cape Shore	45	493,500	12,643	50,000	557	601,700	10,688
Total	211	1,818,000	42,200	361,500	3,833	1,876,200	32,658
West of 66° W. longitude:							
Browns Bank	27	229,000	3,075	69,300	931	323,000	3,248
Georges Bank	466	4,162,200	69,314	308,500	3,778	9,790,000	120,661
Cashes Bank	38	223,000	4,700	127,000	1,388	212,000	3,907
Clark Bank	4	46,000	628			55,000	858
Fippenies Bank	6	17,000	270	4,000	60	19,000	280
Tillies Bank	6	10,500	315	600	6	21,500	645
Middle Bank	213	380,600	9,381	11,100	129	914,000	21,592
Jeffreys Ledge	224	440,700	11,296	33,800	391	1,069,700	26,812
Ipswich Bay	2	7,100	213			1,000	30
South Channel	405	2,678,600	63,868	120,300	1,327	5,624,600	119,139
Nantucket Shoals	310	5,114,600	64,486	2,500	21	300,000	7,768
Off Highland Light	135	398,200	9,550	7,200	32	772,500	16,062
Off Chatham	120	531,200	10,517	11,000	129	1,122,100	23,220
Shore, general	1,918	5,173,000	106,684	142,400	1,620	5,514,150	110,149
Total	3,874	19,411,700	354,297	837,700	9,812	25,738,550	454,371
Grand total	4,085	21,229,700	396,497	1,199,200	13,645	27,614,750	487,029

Fishing-grounds.	Hake. Fresh. Pounds.	Hake. Fresh. Value.	Pollock. Fresh. Pounds.	Pollock. Fresh. Value.	Halibut. Fresh. Pounds.	Halibut. Fresh. Value.	Halibut. Salted. Pounds.	Halibut. Salted. Value.
East of 66° W. longitude:								
La Have Bank	385,500	$3,999	37,200	$415	218,900	$22,467		
Western Bank	198,000	1,471	5,000	66	338,300	28,486		
Grand Bank							106,000	$3,710
Cape Shore	132,500	1,372	13,000	139	21,250	2,458		
Total	716,000	6,842	55,200	620	578,450	53,411	106,000	3,710
West of 66° W. longitude:								
Browns Bank	35,500	393	12,000	100	63,900	5,787		
Georges Bank	589,500	6,081	55,700	642	282,950	26,035		
Cashes Bank	258,200	2,602	11,500	122	5,800	769		
Clark Bank					7,500	770		
Fippenies Bank	29,000	450	1,000	9	500	50		
Tillies Bank	11,500	115	3,000	38				
Middle Bank	242,600	2,683	33,100	331	1,800	199		
Jeffreys Ledge	508,900	5,420	126,100	1,170	650	87		
Ipswich Bay	1,000	10	8,000	60				
South Channel	2,341,000	24,191	79,800	743	56,120	6,116		
Nantucket Shoals	23,400	191	109,600	1,244	3,300	350		
Off Highland Light	298,600	3,287	22,600	213	1,100	128		
Off Chatham	260,600	2,597	36,200	308	7,000	676		
Shore general	1,274,700	13,230	388,350	3,019	33,250	3,234		
Total	5,874,500	61,250	886,950	7,999	463,870	44,201		
Grand total	6,590,500	68,092	942,150	8,619	1,042,320	97,612	106,000	3,710

Summary by fishing-grounds of certain fishery products landed at Boston, Mass., in 1897, by American fishing vessels—Continued.

Fishing-grounds.	Mackerel.				Other fish.			
	Fresh.		Salted.		Fresh.		Salted.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
East of 66° W. longitude:								
La Have Bank					800	$96		
Western Bank							18,000	$255
Grand Bank							1,000	30
Off Newfoundland					1,897,600	16,344		
Cape Shore	18,000	$2,100						
Total	18,000	2,100			1,898,400	16,440	19,000	285
West of 66° W. longitude:								
Georges Bank	410,835	31,268	23,400	$1,690	264,600	24,694		
Middle Bank	1,125	113			4,200	486		
Jeffreys Ledge					6,600	792		
South Channel	246,750	19,840			7,800	702		
Nantucket Shoals	14,645	1,300			31,600	2,844		
Shore general	196,433	13,482	51,200	3,700	984,350	35,104		
Total	869,788	66,003	74,600	5,390	1,299,150	64,622		
Grand total	887,788	68,103	74,600	5,390	3,197,550	81,062	19,000	285

SUMMARY.

Fishing-grounds.	Fresh.		Salted.	
	Pounds.	Value.	Pounds.	Value.
East of 66° W. longitude:				
La Have Bank	2,889,700	$70,934		
Western Bank	1,204,500	40,869	18,000	$255
Grand Bank			107,000	3,740
Off Newfoundland	1,897,600	16,344		
Cape Shore	1,329,950	29,957		
Total	7,321,750	158,104	125,000	3,995
West of 66° W. longitude:				
Browns Bank	732,700	13,534		
Georges Bank	5,864,285	282,473	23,400	1,690
Cashes Bank	837,500	13,488		
Clark Bank	108,500	2,256		
Fippenies Bank	70,500	1,119		
Tillies Bank	47,100	1,119		
Middle Bank	1,588,525	34,914		
Jeffreys Ledge	2,186,450	45,968		
Ipswich Bay	17,100	313		
South Channel	11,154,970	235,926		
Nantucket Shoals	5,599,645	78,204		
Off Highland Light	1,500,200	29,272		
Off Chatham	1,968,100	37,447		
Shore general	13,706,633	286,522	51,200	3,700
Total	55,382,208	1,062,555	74,600	5,390
Grand total	62,703,958	1,220,659	199,600	9,385

FISHERIES OF LAKE ONTARIO.

The fisheries of this lake have been declining for many years. The yield in 1897 was 920,996 pounds of fish, valued at $34,295. These figures, when compared with those for 1893, show that there has been a decrease of 7,019 pounds in products and an increase in value of $2,785. An increase of 136,588 pounds is shown in the catch of whitefish during the same period, the total catch of whitefish for 1897 amounting to 181,968 pounds, valued at $8,936. In 1890, 598,978 pounds of herring were taken, and in 1893 164,998 pounds, whereas the catch for 1897

amounts to only 25,074 pounds. The catch of sturgeon is 101,635 pounds, a decrease of 23,658 pounds since 1893. The total number of persons employed was 248, the capital invested being $35,998. The number of persons engaged has remained nearly stationary, there being a decrease of only 7 since 1893, while the decrease in capital invested amounts to $20,133.

In Lake Ontario no netting is allowed within 1 mile of the shore, except in the waters of Jefferson County and in Mexico Bay, Oswego County. As a result of this law the fishing is practically restricted to gill nets outside of the counties mentioned.

Table showing by counties the number of persons employed in the fisheries of Lake Ontario in 1897.

Counties.	In vessel fisheries.	In shore fisheries.	Total.
Jefferson		103	103
Oswego	5	31	36
Cayuga		9	9
Wayne	5	25	30
Monroe		6	6
Orleans		13	13
Niagara		51	51
Total	10	238	248

Comparative table showing in pounds the yield of the fisheries of Lake Ontario in 1880, 1885, 1890, 1893, and 1897.

Species.	1880.	1885.	1890.	1893.	1897.
Herring (including longjaws)	611,219	403,585	598,978	164,998	46,222
Sturgeon	545,283	386,974	541,752	56,863	101,635
Trout	569,700	20,510	41,010	6,204	2,349
Whitefish	1,064,000	90,711	148,771	45,380	181,968
Other fish	849,800	1,496,686	2,115,937	586,140	586,722
Total	3,640,000	2,398,466	3,446,448	859,585	920,896
Total value	$159,700	$95,869	$124,786	$29,260	$34,295

Table showing by counties and species the yield of the fisheries of Lake Ontario in 1897.

Species.	Jefferson.		Oswego.		Cayuga.		Wayne.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Black bass	22,104	$1,191			2,600	$260	5,000	$350
Blue pike	13,675	620	125	$5			6,946	278
Bloater or longjaw	1,048	33	12,000	420	1,300	104	4,050	210
Bullheads	103,654	2,307	16,000	400	1,600	80	1,840	74
Catfish	1,750	53						
Eels	65,419	1,677	500	20				
Herring, fresh	10,324	369	2,500	75			5,990	240
Herring, salted	2,860	261						
Mullet	7,947	81	5,405	108				
Perch	82,812	946			10,150	507	35,845	1,434
Pickerel	39,964	1,349			5,990	299	17,144	686
Rock bass	6,376	65						
Sturgeon	42,593	2,165	14,706	883			10,653	799
Suckers	26,558	269	10,500	204			520	5
Sunfish	17,723	178						
Trout	2,475	101						
Whitefish	10,617	471	13,500	540			5,477	449
Wall-eyed pike	4,594	254					22	1
Total	462,493	12,390	75,236	2,655	21,640	1,250	93,487	4,526

Table showing the yield of the fisheries of Lake Ontario in 1897—Continued.

Species.	Monroe.		Orleans.		Niagara.		Total.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Black bass							29,704	$1,801
Blue pike			880	$44	27,368	$1,031	48,994	1,978
Bloater or longjaw	2,600	$104			350	11	21,348	882
Bullheads					100	4	123,194	2,865
Catfish							1,750	53
Eels							65,919	1,697
Herring, fresh	3,350	144			50	2	22,214	830
Herring, salted							2,860	261
Ling					1,892	46	1,892	46
Mullet							13,352	189
Perch	8,000	293	2,255	113	30,192	1,484	169,254	4,777
Pickerel	1,160	47					64,258	2,381
Rock bass							6,376	65
Sand pike					233	12	233	12
Sturgeon	3,700	278	9,853	740	20,130	1,517	101,635	6,382
Suckers	1,040	10			1,500	51	40,118	539
Sunfish							17,723	178
Trout					374	29	2,849	130
White bass					739	38	739	38
Whitefish	2,000	160	11,825	706	138,549	6,610	181,968	8,936
Wall-eyed pike							4,616	255
Total	21,850	1,036	24,813	1,603	221,477	10,835	920,996	34,295

Table showing by counties the vessels, boats, apparatus, and shore property employed in the fisheries of Lake Ontario in 1897.

Designation.	Jefferson.		Oswego.		Cayuga.		Wayne.	
	No.	Value.	No.	Value.	No.	Value.	No.	Value.
Vessels fishing							1	$3,750
Tonnage							42.41	
Outfit								70
Vessels transporting			1	$2,000				
Tonnage			13.69					
Outfit				240				
Boats	77	$4,551	13	655	9	$560	22	650
Apparatus of capture:								
Gill nets ....feet	66,104	1,932	38,877	908	30	2	53,640	1,165
Trap nets	111	3,850						
Fyke nets	115	1,150					14	70
Seines	8	205	5	1,280				
Hand lines	40	60			33	30	20	8
Set lines ....feet			90,400	444			39,600	105
Spears	4	4						
Shore property		2,093		2,585				435
Total		13,845		8,112		592		6,253

Designation.	Monroe.		Orleans.		Niagara.		Total.	
	No.	Value.	No.	Value.	No.	Value.	No.	Value.
Vessels fishing							1	$3,750
Tonnage							42.41	
Outfit								70
Vessels transporting							1	2,000
Tonnage							13.69	
Outfit								240
Boats	4	$300	7	$380	30	$1,475	162	8,571
Apparatus of capture:								
Gill nets ....feet	31,432	670	15,055	597	84,282	2,080	289,420	7,354
Trap nets							111	3,850
Fyke nets	15	75					144	1,295
Seines							13	1,485
Hand lines							93	98
Set lines ....feet	10,560	20	23,760	70	33,000	67	197,320	706
Spears							4	4
Shore property		300		185		977		6,575
Total		1,365		1,232		4,599		35,998

Table showing by counties, apparatus, and species the yield of the fisheries of Lake Ontario in 1897.

Apparatus and species.	Jefferson.		Oswego.		Cayuga.		Wayne.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Gill nets:								
Blue pike	10,085	$481	75	$3	...	...	6,946	$278
Bullheads	1,910	42	...	...	1,600	$80	1,840	74
Bloater or longjaw	1,048	33	12,000	420	1,300	104	4,050	210
Herring, fresh	9,324	339	2,500	75	...	...	5,990	240
Herring, salted	2,860	261	...	...	...	...	...	...
Mullet	558	7	...	...	...	...	...	...
Perch	12,858	157	...	...	2,200	110	29,845	1,194
Pickerel	8,009	239	...	...	...	...	10,604	424
Rock bass	671	7	...	...	...	...	...	...
Sturgeon	32,906	1,767	6,906	414	...	...	7,853	589
Suckers	4,883	49	600	6	...	...	...	...
Trout	2,475	101	...	...	...	...	...	...
Whitefish	4,992	221	7,500	300	...	...	5,477	449
Wall-eyed pike	356	15	...	...	...	...	22	1
Total	92,935	3,719	29,581	1,218	5,100	294	72,627	3,459
Trap nets:								
Black bass	6,890	346	...	...	...	...	...	...
Blue pike	3,590	139	...	...	...	...	...	...
Bullheads	41,894	1,043	...	...	...	...	...	...
Catfish	1,150	35	...	...	...	...	...	...
Eels	47,204	1,201	...	...	...	...	...	...
Herring	1,000	30	...	...	...	...	...	...
Mullet	5,924	60	...	...	...	...	...	...
Perch	46,311	468	...	...	...	...	...	...
Pickerel	15,722	475	...	...	...	...	...	...
Rock bass	5,025	51	...	...	...	...	...	...
Sturgeon	9,487	384	...	...	...	...	...	...
Suckers	12,820	131	...	...	...	...	...	...
Sunfish	12,499	125	...	...	...	...	...	...
Whitefish	5,625	250	...	...	...	...	...	...
Wall-eyed pike	3,758	214	...	...	...	...	...	...
Total	218,899	4,952	...	...	...	...	...	...
Fyke nets:								
Black bass	1,000	50	...	...	...	...	...	...
Bullheads	50,700	998	...	...	...	...	19,400	679
Eels	15,215	390	...	...	...	...	...	...
Mullet	625	6	...	...	...	...	...	...
Perch	13,100	146	...	...	...	...	...	...
Pickerel	6,260	205	...	...	...	...	2,540	102
Suckers	3,665	37	...	...	...	...	520	5
Sunfish	1,924	20	...	...	...	...	5,800	116
Wall-eyed pike	250	13	...	...	...	...	...	...
Total	92,739	1,865	...	...	...	...	28,260	902
Seines:								
Black bass	75	4	...	...	...	...	...	...
Blue pike	...	...	50	2	...	...	...	...
Bullheads	9,150	224	16,000	400	...	...	...	...
Catfish	600	18	...	...	...	...	...	...
Eels	2,350	69	500	20	...	...	...	...
Mullet	840	8	5,405	108	...	...	...	...
Perch	8,425	154	...	...	...	...	...	...
Pickerel	9,878	427	...	...	...	...	...	...
Rock bass	680	7	...	...	...	...	...	...
Sturgeon	200	14	...	...	...	...	...	...
Suckers	5,190	52	9,900	198	...	...	...	...
Sunfish	3,300	33	...	...	...	...	...	...
Whitefish	...	...	6,000	240	...	...	...	...
Wall-eyed pike	230	12	...	...	...	...	...	...
Total	40,918	1,022	37,855	968	...	...	...	...
Hand lines:								
Black bass	14,139	791	...	...	2,600	260	5,000	350
Perch	2,118	21	...	...	7,950	397	6,000	240
Pickerel	95	3	...	...	5,990	299	4,000	160
Total	16,352	815	...	...	16,540	956	15,000	750
Set lines:								
Sturgeon	...	...	7,800	469	...	...	2,800	210
Spears:								
Eels	650	17	...	...	...	...	...	...
Grand total	462,493	12,390	75,236	2,655	21,640	1,250	118,687	5,321

Table showing by counties, apparatus, and species the yield of the fisheries of Lake Ontario in 1897—Continued.

Apparatus and species.	Monroe.		Orleans.		Niagara.		Total.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Gill nets:								
Blue pike			880	$44	27,368	$1,031	45,354	$1,837
Bullheads					100	4	5,450	200
Bloater or longjaw	2,600	$104			350	11	21,348	882
Herring, fresh	3,350	144			50	2	21,214	800
Herring, salted							2,860	261
Ling					1,892	46	1,892	46
Mullet							558	7
Perch	8,000	293	2,255	113	30,192	1,484	85,350	3,351
Pickerel	50	3					18,663	666
Rock bass							671	7
Sand pike					233	12	233	12
Sturgeon	167	13	3,204	240	14,050	1,061	65,086	4,084
Suckers	1,040	10			1,500	51	8,023	116
Trout					374	29	2,849	130
White bass					739	38	739	38
Whitefish	2,000	160	11,825	706	138,549	6,610	170,343	8,446
Wall-eyed pike							378	16
Total	17,207	727	18,164	1,103	215,397	10,379	451,011	20,899
Trap nets:								
Black bass							6,890	346
Blue pike							3,590	139
Bullheads							41,894	1,043
Catfish							1,150	35
Eels							47,204	1,201
Herring							1,000	30
Mullet							5,924	60
Perch							46,311	468
Pickerel							15,722	475
Rock bass							5,025	51
Sturgeon							9,487	384
Suckers							12,820	131
Sunfish							12,499	125
Whitefish							5,625	250
Wall-eyed pike							3,758	214
Total							218,899	4,952
Fyke nets:								
Black bass							1,000	50
Bullheads	7,280	255					77,380	1,932
Eels							15,215	390
Mullet							625	6
Perch							13,100	146
Pickerel	1,110	44					9,910	351
Suckers							4,185	42
Sunfish	1,400	14					9,124	150
Wall-eyed pike							250	13
Total	9,790	313					130,789	3,080
Seines:								
Black bass							75	4
Blue pike							50	2
Bullheads							25,150	624
Catfish							600	18
Eels							2,850	89
Mullet							6,245	116
Perch							8,425	154
Pickerel							9,878	427
Rock bass							680	7
Sturgeon							200	14
Suckers							15,090	250
Sunfish							3,300	33
Whitefish							6,000	240
Wall-eyed pike							230	12
Total							78,773	1,990
Hand lines:								
Black bass							21,739	1,401
Perch							16,068	658
Pickerel							10,085	462
Total							47,892	2,521
Set lines:								
Sturgeon	3,533	265	6,649	500	6,080	456	26,862	1,900
Spears:								
Eels							650	17
Grand total	30,530	1,305	24,813	1,603	221,477	10,835	954,876	35,359

FISHERIES OF THE SOUTH ATLANTIC STATES IN 1897.

Investigations of the fisheries of these States were carried on during March, April, and May, 1898, Mr. Wilcox canvassing Georgia and South Carolina, and Messrs. Cogswell and Cobb North Carolina. The east coast of Florida was covered by Mr. Cobb during the preceding autumn, and data collected for the fiscal year 1897. The general results of the work, as set forth in the following tables, show an increase in the fisheries since the last canvass, which was made in 1890.

The number of persons engaged was 17,185, of whom 14,449 were fishermen and 2,736 shoresmen.

The capital invested ($1,828,832) is apportioned as follows: Vessels and their outfits, $200,280; boats, $276,866; apparatus of capture, $492,597; shore property and cash capital, $859,090.

The products of the fisheries amounted to 80,390,465 pounds, with a first value of $1,833,155. There has been an increase in the number of persons employed of 1,184; in capital invested of $140,546; in products of 13,205,847 pounds; and in value of products of $259,451. The shad and oyster fisheries lead in the list of products, the former being valued at $478,784 and the latter at $384,934. The fisheries of North and South Carolina and Georgia have increased to some extent, while those of the east coast of Florida have decreased. The decrease in Florida has been chiefly in the shad fishery, which has less than half the importance in yield and value which it had in 1890. This is said to be due to the great spread of the water hyacinth in the St. Johns River, which prevents the use of seines. There has been an important increase in the yield and value of shad and oysters in North Carolina and Georgia, and of oysters in South Carolina.

Number of persons employed in the fisheries of the South Atlantic States in 1897.

States.	Fishermen.	Shoresmen.	Total.
North Carolina	10,120	1,925	11,045
South Carolina	1,934	205	2,139
Georgia	1,404	465	1,869
Florida	991	141	1,132
Total	14,449	2,736	17,185

Table showing the number and value of vessels, boats, apparatus, and shore property employed in the fisheries of the South Atlantic States in 1897.

Items.	North Carolina.		South Carolina.		Georgia.		Florida.		Total.	
	No.	Value.	No.	Value.	No.	Value.	No.	Value.	No.	Value.
Vessels	174	$122,625	16	$12,000	51	$21,425	2	$2,400	243	$158,450
Tonnage	1,879.23		252.93		641.80		16.87		2,790.83	
Outfit		28,750		3,742		7,408		1,930		41,830
Boats	4,428	202,709	1,056	34,080	680	20,277	527	19,800	6,691	276,866
Apparatus of capture		410,811		30,677		17,898		33,210		492,597
Shore and accessory property		315,164		45,055		106,356		64,715		531,290
Cash capital		138,400		48,800		111,500		29,100		327,800
Total		1,218,459		174,354		284,864		151,155		1,828,832

Table showing the quantity and value of products taken in the fisheries of the South Atlantic States in 1897.

Species.	North Carolina.		South Carolina.		Georgia.		Florida.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Alewives, fresh	5,694,201	$48,756	2,000	$40	25,000	$500	33,913	$404
Alewives, salted	10,096,236	78,299					5,000	125
Black bass	535,342	23,611	1,000	30	4,600	822	52,516	2,184
Bluefish, fresh	1,482,375	41,608	40,000	1,600			46,421	1,121
Bluefish, salted	213,800	5,144						
Bonito	2,350	35						
Bream and sunfish	38,210	1,000			3,900	195	248,989	6,827
Butterfish	94,750	1,758						
Catfish	192,211	4,646	28,500	535	157,600	2,734	124,000	3,720
Channel bass or redfish, fresh	64,550	830	110,000	2,500	23,800	1,190	235,782	3,542
Channel bass or redfish, salted	40,200	804						
Drum	51,400	1,073	215,000	1,875	14,300	592	17,000	175
Eels	96,700	4,051			5,000	100		
Flounders	173,975	3,199			6,500	290		
Groupers			33,000	1,170				
Hickory shad	230,975	7,583	36,800	1,516	7,775	262		
Kingfish	358,070	7,628						
Menhaden	11,310,000	19,700						
Mullet, fresh	797,425	16,797	46,000	885	56,000	1,310	2,341,957	21,156
Mullet, salted	2,612,160	73,541	10,000	200			71,400	1,576
Perch	806,379	24,044	2,000	40	3,600	140		
Pigfish	412,807	10,285						
Pike	100,420	2,655						
Pinfish	61,600	1,064						
Pompano	53,175	1,728	5,000	300			196,344	13,093
Porgy	39,910	472						
Sailors' choice	39,000	975	8,800	440	600	30		
Scad or round robin	8,100	46						
Sea bass	189,225	5,564	632,400	26,356			5,570	210
Shad	8,963,488	362,811	506,125	27,696	787,550	46,705	1,011,180	41,572
Sharks			30,000	300				
Sheepshead	271,206	9,243	36,200	1,460	25,000	1,250	390,164	5,908
Snappers	34,400	860	54,000	1,660				
Spanish mackerel	330,840	18,017	10,000	1,000	18,100	655	3,450	160
Spots and croakers, fresh	1,963,756	28,384	49,000	730			23,133	772
Spots and croakers, salted	165,246	4,749						
Squeteague, fresh	3,006,758	92,993	80,000	2,030	54,650	2,512	516,370	12,817
Squeteague, salted	83,496	2,226						
Strawberry bass	21,725	866						
Striped bass	845,123	58,035	10,100	556	9,000	530		
Sturgeon	371,625	13,525	411,100	7,325	147,700	4,060		
Suckers	135,230	3,037						
Tautog	14,125	283						
Warmouth bass	6,950	348						
Whiting	45,300	1,133	638,500	28,405	45,700	2,100	8,000	365
Other fish							103,340	3,356
Shrimp	146,496	5,885	374,500	18,395	67,600	2,535	38,625	1,497
Crabs, soft	986,720	3,992						
Crabs, hard	40,000	1,000	110,000	2,240	74,660	1,864	3,700	175
Crawfish							4,000	80
Terrapins	17,179	2,815	40,916	9,635	34,785	11,254	10,350	1,425
Turtles	24,000	1,920			1,000	20	23,856	1,751
Frogs	1,800	450						
Oysters	6,011,726	241,099	1,504,300	45,360	3,406,440	86,709	362,802	11,766
Clams	937,808	53,703	185,400	8,652	2,640	165	4,800	300
Scallops	118,323	5,653						
Caviar	32,500	11,162	69,805	17,525	9,600	2,581		
Trout sounds	691	104						
Refuse	3,862,200	4,828						
Total	64,234,257	1,316,017	5,280,446	210,456	4,993,100	170,605	5,882,662	136,077

Table showing the quantity and value of products taken in the fisheries of the South Atlantic States in 1897—Continued.

Species.	Total.		Species.	Total.	
	Pounds.	Value.		Pounds.	Value.
Alewives, fresh	5,755,114	$49,700	Sharks	30,000	$300
Alewives, salted	10,101,236	78,424	Sheepshead	722,570	17,861
Black bass	593,458	26,147	Snappers	88,400	2,520
Bluefish, fresh	1,568,796	44,329	Spanish mackerel	362,390	19,832
Bluefish, salted	213,800	5,144	Spots and croakers, fresh	2,035,889	29,886
Bonito	2,350	35	Spots and croakers, salted	165,246	4,749
Bream and sunfish	291,099	8,022	Squeteague, fresh	3,657,778	110,352
Butter-fish	94,750	1,758	Squeteague, salted	83,496	2,226
Catfish	502,311	11,635	Strawberry bass	21,725	866
Channel bass or redfish, fresh	434,132	8,062	Striped bass	864,223	59,121
Channel bass or redfish, salted	40,200	804	Sturgeon	930,425	24,910
Drum	297,700	3,715	Suckers	135,230	3,037
Eels	101,700	4,151	Tautog	14,125	283
Flounders	180,475	3,489	Warmouth bass	6,950	348
Groupers	33,000	1,170	Whiting	737,500	32,003
Hickory shad	275,550	9,361	Other fish	103,340	3,356
Kingfish	358,070	7,628	Shrimp	627,221	28,312
Menhaden	11,310,000	19,700	Crabs, soft	986,720	3,992
Mullet, fresh	3,241,382	40,148	Crabs, hard	228,360	5,279
Mullet, salted	2,693,560	75,317	Crawfish	4,000	80
Perch	811,979	24,224	Terrapins	103,230	25,129
Pigfish	412,807	10,285	Turtles	48,856	3,691
Pike	100,420	2,655	Frogs	1,800	450
Pinfish	61,600	1,064	Oysters	11,285,268	384,934
Pompano	254,519	15,121	Clams	1,130,648	62,820
Porgy	39,910	472	Scallops	118,323	5,653
Sailor's choice	48,400	1,445	Caviar	111,905	31,268
Scad or round robin	8,100	46	Trout sounds	691	104
Sea bass	827,195	32,130	Refuse	3,862,200	4,828
Shad	11,268,343	478,784	Total	80,390,465	1,833,155

FISHERIES OF THE GULF STATES IN 1897.

The canvass of the commercial fisheries of this region was conducted chiefly during March, April, and May, 1898, by Messrs. Stevenson and Hall, the former working in Louisiana and Texas and the latter in Mississippi and Alabama.

The statistics of the west coast of Florida were collected in the autumn of 1897 by Mr Cobb, and refer to the preceding fiscal year.

From the information collected it is shown that there were employed in fisheries of the Gulf States 13,967 persons, 11,180 of whom were fishermen and 2,787 shoresmen. The capital invested in the fisheries amounted to $2,584,061, of which $717,076 represented vessels and their outfits, $436,041 boats, $137,216 apparatus of capture, and $1,293,728 shore property and cash capital.

The products of the fisheries amounted to 65,660,623 pounds, having a first value of $2,271,726. The oyster fishery was valued at $748,760, or more than twice the value of any other single fishery. Next in importance is the sponge fishery, valued at $305,589. The catch of red snappers was valued at $200,412, and that of mullet at $213,988, all other fisheries being represented by smaller sums.

A comparison of the results of the present canvass with those of the canvass in 1890 shows that 2,215 more persons were employed. There has been a slight decrease in other respects, as follows: $394,231 less capital invested, 3,714,911 less pounds of products, and a reduction in value of products of $166,949.

In the different States there are numerous changes to be noted in the yield of the various fisheries. The oyster fishery shows a great reduction in products and value in Florida, Alabama, Mississippi, and Texas, and an important increase in Louisiana. The red-snapper fishery has greatly increased in Florida, Alabama, and Texas, while in Louisiana it has been abandoned or transferred elsewhere. The mullet fishery has increased in yield and value in Florida; in yield but not in value in Alabama, and has decreased in both respects in the other three States. A decrease is to be noticed in the sponge fishery of Florida. There has been an increase in the shrimp fishery in Alabama, Mississippi, and Texas, and a decrease in Louisiana.

The important increase in the number of persons engaged in the fisheries warrants the assumption that an increase would have been found in the general yield and value of the fisheries of the Gulf region had they not been affected by outside agencies. There can be little doubt that the decrease is due largely to the restrictions placed on the various means of transportation during the yellow-fever outbreak of 1897.

Table showing by States the number of persons engaged in the fisheries of the Gulf States in 1897.

States.	Fishermen.	Shoresmen.	Total.
Florida	4,667	344	5,011
Alabama	593	196	789
Mississippi	1,061	1,504	2,565
Louisiana	3,719	684	4,403
Texas	1,140	59	1,199
Total	11,180	2,787	13,967

Table showing by States the investment in the fisheries of the Gulf States in 1897.

Designation.	Florida.		Alabama.		Mississippi.	
	No.	Value.	No.	Value.	No.	Value.
Vessels	183	$274,177	53	$40,375	83	$81,125
Tonnage	2,771.02		522.18		854.88	
Outfit		191,561		10,570		25,938
Boats	1,621	130,548	254	12,939	439	17,039
Apparatus of capture		54,350		9,205		19,255
Shore property		175,526		49,350		125,644
Cash capital		323,100		42,750		249,300
Total		1,149,262		165,189		518,301

Designation.	Louisiana.		Texas.		Total.	
	No.	Value.	No.	Value.	No.	Value.
Vessels	61	$32,101	45	$36,565	425	$464,343
Tonnage	395.80		508.81		5,052.69	
Outfit		9,545		15,119		252,733
Boats	3,025	197,604	686	77,911	6,025	436,041
Apparatus of capture		31,660		22,746		137,216
Shore property		173,903		55,155		579,578
Cash capital		69,000		30,000		714,150
Total		513,813		237,496		2,584,061

Table showing by States the products of the fisheries of the Gulf States in 1897.

Species.	Florida.		Alabama.		Mississippi.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Amber-fish	18,600	$620				
Angel-fish	59,186	1,696	6,000	$115		
Barracuda	31,000	1,240				
Black bass			41,000	2,870	27,000	$1,350
Bluefish	264,971	6,057	204,500	4,094	33,300	1,105
Bream and sunfish	7,909	238	79,509	2,783	24,800	508
Buffalo-fish					21,500	215
Catfish	5,000	100	188,000	2,872	31,200	720
Channel bass or redfish	236,368	3,597	213,000	7,425	199,000	8,303
Crevalle	38,140	494	12,000	180		
Drum, salt-water	37,855	622	6,000	91	5,000	250
Flounders	32,561	549	47,000	1,602	28,200	1,002
Groupers	781,155	9,349	69,000	1,035		
Grunts	671,876	16,833				
Hogfish	81,600	3,480				
Jurel	7,500	75				
Kingfish	440,000	6,600				
Ladyfish	123,223	2,633				
Mullet, fresh	11,711,041	126,124	591,300	8,487	240,600	2,881
Mullet, salted	2,432,277	54,928	6,000	195		
Mullet roe, salted	143,999	13,310				
Perch			5,000	200	5,000	150
Pike and pickerel			4,000	61		
Pinfish			4,000	61	38,880	1,314
Pompano, fresh	359,151	17,964	60,300	4,212	24,800	1,580
Pompano, salted	23,225	1,236				
Porgies	98,200	2,450				
Porkfish	11,962	1,196				
Sailors' choice	89,381	3,198				
"Sardines"	150,000	3,090				
Sheepshead	663,347	9,793	86,800	2,949	110,150	4,103
Snappers, red	5,314,487	171,234	335,000	11,725		
Snappers, other	110,631	3,296				
Spanish mackerel, fresh	456,322	21,757	85,500	3,960	64,760	5,076
Spanish mackerel, salted	23,579	1,193				
Spots and croakers	26,113	495	504,000	8,099	51,900	1,914
Sturgeon	9,254	331				
Trout, fresh	703,830	15,148	296,100	9,711	452,800	15,570
Trout, salted	63,105	2,524				
Whiting	9,589	109	2,000	70		
Yellowtail	73,440	6,594				
Other fish	537,138	24,317				
Sponges	332,856	305,589				
Oysters	1,258,008	50,258	1,785,438	60,207	4,407,992	110,964
Clams	7,084	171				
Shrimp			40,600	609	1,903,165	28,804
Crawfish	157,500	3,150				
Crabs, hard	6,240	208	24,400	505	131,640	3,494
Crabs, soft					21,200	1,720
Turtles	634,616	22,736				
Terrapin	11,400	1,250	2,934	320	6,798	1,275
Conchs	500	30				
Alligator hides		12,450				
Otter skins		14,481				
Total	28,255,219	944,793	4,699,381	134,438	7,829,685	192,298

Species.	Louisiana.		Texas.		Total.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Amber-fish					18,600	$620
Angel-fish					65,186	1,811
Barracuda					31,000	1,240
Black bass	320	$26			68,320	4,246
Bluefish	3,960	132	29,540	$1,281	536,271	12,669
Bream and sunfish	119,780	3,789			231,998	7,318
Buffalo-fish	311,093	4,768	12,200	470	344,793	5,453
Catfish	2,153,134	51,420	71,230	3,035	2,448,564	58,147
Channel bass or redfish	465,200	20,529	1,144,376	51,922	2,257,944	91,776
Crevalle	18,000	690	18,000	743	86,140	2,107
Drum, fresh-water	7,250	74			7,250	74
Drum, salt water	18,570	540	50,400	2,046	117,825	3,549
Flounders	9,625	654	218,025	9,819	335,411	13,626
Groupers			3,463	84	853,618	10,468
Grunts					671,876	16,833
Hogfish	125	5	15,995	784	97,720	4,269
Jewfish			33,281	1,083	33,281	1,083

Table showing by States the products of the fisheries of the Gulf States in 1897—Cont'd.

Species.	Louisiana.		Texas.		Total.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Jurel					7,500	$75
Kingfish					440,000	6,600
Ladyfish					123,223	2,633
Mullet, fresh	165,819	$5,871	60,350	$2,167	12,769,110	145,530
Mullet, salted			500	25	2,438,777	55,148
Mullet roe, salted					143,999	13,310
Perch	11,050	500	32,150	1,506	53,200	2,356
Pike and pickerel			22,730	989	26,730	1,050
Pinfish					42,880	1,375
Pompano, fresh	17,665	1,891	17,850	812	479,766	26,459
Pompano, salted					23,225	1,236
Porgies					98,200	2,450
Porkfish					11,962	1,196
Sailors' choice					89,381	3,198
"Sardines"					150,000	3,090
Sheepshead	238,010	12,506	467,504	21,723	1,565,811	51,074
Shoemaker	9,600	346			9,600	346
Silver perch	3,015	128			3,015	128
Snappers, red			464,791	17,453	6,114,278	200,412
Snappers, other					110,631	3,296
Spanish mackerel, fresh	55,805	5,132	40,710	1,939	703,097	37,864
Spanish mackerel, salted					23,579	1,193
Spots and croakers	328,775	16,980	136,700	6,007	1,047,488	33,495
Striped bass	22,880	1,449	8,950	384	31,830	1,833
Sturgeon			22,400	984	31,654	1,315
Trout, fresh	566,648	26,500	1,011,620	45,525	3,030,998	112,454
Trout, salted					63,105	2,524
Whiting					11,589	179
Yellow-tail					73,440	6,594
Other fish	66,550	3,583	60,500	2,646	664,188	30,546
Sponges					332,856	305,589
Oysters	6,714,330	432,668	2,491,370	94,663	16,657,138	748,760
Clams					7,084	171
Shrimp	4,486,726	80,576	360,530	7,464	6,791,021	117,453
Crawfish	84,950	3,113			242,450	6,263
Crabs, hard	1,458,833	12,891	138,120	3,689	1,759,233	20,787
Crabs, soft					21,200	1,720
Turtles	22,395	581	237,385	6,860	894,396	30,177
Terrapin	41,680	4,149	3,880	507	66,692	7,501
Conchs					500	30
Alligator hides		22,096				34,546
Otter skins						14,481
Total	17,401,788	713,587	7,174,550	286,610	65,660,623	2,271,726

FISHERIES OF SOUTHERN CALIFORNIA.

Recently a market has been found in Kansas, Texas, Missouri, and other States west of the Mississippi for fresh fish and spiny lobsters from southern California. Important shipments have been made, chiefly from San Pedro and San Diego, the principal species shipped being barracuda, bonito, mackerel, sea bass, red rockfish and spiny lobsters. Good prices were received, and it is probable that a permanent market for southern California fresh fish will be found. The spiny lobster proved especially desirable; it was shipped chiefly to Kansas City, where it is known as the Bermuda lobster. The scarcity of suitable fishing boats proved a considerable drawback in filling orders for fish from eastern points. In March and April, 1898, Mr. Cloudsley Rutter made inquiries respecting the fisheries of San Diego. Several dealers kept no records, and it is probable that the quantity of fish taken was greater than that accounted for in the following table. More than 800,000 pounds were handled, of which 283,658 pounds were shipped by rail to eastern points.

Statement of the pounds of fish and lobsters handled by San Diego dealers in 1897.

Species.	January.	February	March.	April.	May.	June.	July.
Barracuda	....	450	17,675	34,565	23,345	28,925	24,590
Bonito "mackerel"	801	167	594	2,943	945	594	927
Yellow-tail	960	1,300	1,260	2,770	4,490	5,060	4,290
Albacore	120	20	....	....	....	....	....
Bullseye mackerel	....	....	27	115	160	15	15
"Smelt"	138	105	40	98	....	....	....
Bass	996	1,479	1,414	1,242	745	2,995	4,898
Jewfish	40	150	125	....	....	50	....
Monterey halibut	7,503	7,187	8,657	9,954	1,894	2,353	3,050
Rockfishes	5,655	3,752	2,879	777	185	....	81
Yellow-fin	....	10	27	13	30	77	....
Sea trout	....	....	....	380	495	....	....
Scorbina	....	....	....	....	....	103	223
Fat-head redfish	151	258	45	....	....	....	....
Whitefish	277	1,140	918	....	....	....	....
Kingfish	....	178	....	132	....	....	....
Herring	711	340	....	....	....	....	....
Other fish	379	257	5,616	3,428	2,517	672	2,909
Total fresh	17,731	16,793	39,277	56,417	34,806	40,844	40,983
Salted fish: Barracuda, bonito, yellow-tail, albacore, and rockfish	....	25,854	30,782	9,436	27,716	29,481	52,535
Grand total of fish	17,731	42,647	70,059	65,853	62,522	70,325	93,518
Spiny lobsters	116	25	158	1,689	1,791	....	3,229
Shipment of fresh fish and lobsters by rail	16,122	8,381	19,245	28,230	25,675	26,414	29,093

Species.	August.	September.	October.	November.	December.	Date unknown.	Total.
Barracuda	32,535	18,895	3,520	80	40	....	184,620
Bonito "mackerel"	1,188	4,077	8,217	1,332	324	....	22,109
Yellow-tail	4,820	5,530	9,070	1,700	2,100	....	43,350
Albacore	....	90	690	420	....	....	1,340
Bullseye mackerel	43	9	....	....	....	....	384
"Smelt"	....	20	58	905	485	....	1,849
Bass	4,474	8,843	5,193	509	2,812	....	35,600
Jewfish	....	200	60	55	300	....	980
Monterey halibut	6,042	6,555	8,296	5,595	8,142	....	75,228
Rockfishes	....	1,666	6,525	20,552	15,965	....	58,037
Yellow-fin	....	....	....	652	34	....	843
Sea trout	....	....	....	....	....	....	875
Scorbina	*4,837	474	101	22	....	....	5,760
Fat-head redfish	....	180	655	2,748	532	....	4,569
Whitefish	....	56	543	1,950	975	....	5,859
Mullet	....	....	....	1,286	152	....	1,438
Kingfish	....	....	123	281	112	....	826
Herring	....	....	....	310	3,966	....	5,327
Other fish	1,267	936	280	1,551	1,565	†14,000	35,377
Total fresh	55,206	47,531	43,331	39,948	37,504	14,000	484,371
Salted fish: Barracuda, bonito, yellow-tail, albacore, and rockfish	40,160	50,859	15,776	48,199	22,919	11,000	364,717
Grand total of fish	95,366	98,390	59,107	88,147	60,423	25,000	849,088
Spiny lobsters	8,640	8,596	7,412	10,955	4,934	....	47,545
Shipment of fresh fish and lobsters by rail	32,758	30,118	23,645	21,412	22,565	....	283,658

* Not sure that the figures were for this species. † Estimated.

The following notes on the fishing apparatus employed at San Diego have been furnished by Mr. Rutter:

Trolling is the method used in catching barracuda, bonito, yellow-tail, and albacore. A No. 4 I. P. cod hook is used for barracuda, No. 3 for bonito, and No. 2 for yellow-tail and albacore. But nearly all of these fishes are caught when trolling for barracuda, as there are usually not enough of the others to pay for special fishing. When the fish are abundant, and there is a man for each line, the barb is

usually filed off or bent down. This is to facilitate removing the fish from the hook. Six to 10 fathoms of No. 48 line is used. The gig is fastened to the line by a wire about 3 feet long.

In fishing for halibut, bass, and other bottom fishes, the trawl is used almost exclusively. A trawl is made with No. 120 to 140 line, with 160 hooks hung 7 feet apart on ganging of No. 27 line 3 feet long. Any number of trawls may be fastened end to end. No. 7/0 Kirby hooks are generally used, but No. 8/0 are better for halibut, and No. 5/0 or 6/0 for bass, whitefish, or yellow-fin. The trawl is lifted about every half hour.

In fishing for rockfish, a No. 48 line is used, with about thirty or forty No. 7/0 Kirby hooks fastened near one end. This is fished from the boat, never set like a trawl. Sometimes an ordinary trawl is used for rockfish, but the ground is usually rocky, and a part of the line is often lost. When the line is caught, it is often loosened by sliding a 20 to 25 pound iron ring down over it. The ring is about 7 inches inside diameter and is lowered by a small rope. A trawl for rockfish is lifted within about five minutes after setting. For all kinds of bottom fishing the sardine is the principal bait used. Shallow baskets with cork rims are used for coiling the trawls, the hooks being stuck into the rim.

Barracuda are sometimes caught in gill-nets. These are of 3½-inch mesh, 16 to 20 feet deep, and about 200 fathoms long, made of No. 9 thread. Silversides are caught in gill-nets of 2-inch mesh, 16 feet deep, length variable. Sardine gill-nets are of 1¼-inch mesh and 12 feet deep. All gill-nets drift. They are used chiefly for silversides (smelt) and sardines, but not much for barracuda.

Drag seines are used only in the bay. The common size is about 10 feet deep and 200 fathoms long. The mesh at the ends is about 3½ inches; about 30 fathoms from the end it is 2 inches; in the middle about 1 inch. The bag is about 15 feet across and 10 feet long, the mesh about ¾ inch.

Trammel nets are sometimes used for bottom fishes. The outer nets are of 16-inch mesh of about No. 15 twine, the inner net of 3½ or 4 inch mesh of about No. 8 twine. The net is 6 to 9 feet deep; length variable.

THE AMERICAN SEAL HERD AND PELAGIC SEALING.

In compliance with an act of Congress, an investigation of the condition of the Pribilof fur-seal rookeries has been made by the Fish Commission each year since 1893. This work has usually been performed by the writer in connection with former duties on the steamer *Albatross*. In 1896–97 the existence of a special fur-seal investigation commission, with which the writer was connected, made it unnecessary for the Fish Commission to make separate reports on the subject. During the past season he resumed the fur-seal investigations in connection with the work of the division of fisheries, leaving Washington for the Pribilof Islands in June. This was authorized by the Commissioner upon the request of the Secretary of the Treasury, in accordance with the direction of the President, that a systematic study of the Pribilof seal herd be maintained from year to year.

Pelagic sealing is no longer engaged in by citizens of the United States, Congress having passed a law in December, 1897, prohibiting the killing of fur-seals in the waters of the North Pacific Ocean, and the importation of skins so taken, whether raw or manufactured.

The business, so far as the American seal herd is concerned, is now engaged in by Canadians only. The catch by the Canadian fleet off the northwest coast during the winter of 1897 amounted to 10,055 seals.

The pelagic sealing industry declines steadily from year to year, as well as the sealing industry conducted on the Pribilof Islands under the direction of the United States Government. The continuation of the former, with its indiscriminate methods of seal killing, is directly responsible for the reduced condition of the latter. Since 1896 the catch of superfluous male seals on the Pribilof Islands has been: 1896, 28,964; 1897, 20,890; 1898, 18,032. From 1871 to 1889 the islands yielded an average of 100,000 surplus males a year. The pelagic catch from the American herd has of late years decreased as follows: 1894, 61,838; 1895, 56,291; 1896, 43,917; 1897, 24,322.

Pelagic sealing off the Asiatic coast has been practically abandoned by the Canadian fleet, the Asiatic herd having become so reduced that good catches can no longer be made.

SALMON FISHING IN THE YUKON RIVER.

The fishery resources of the great Yukon River, hitherto never drawn upon except by native tribes, now give promise of some development. It has long been known that there was an important run of salmon in this river, but little information existed as to the range and abundance of the different species in the region of the boundary between Alaska and the Northwest Territory. The information at hand respecting the fishing operations now conducted by whites is fragmentary, but it appears that salmon are sufficiently abundant along the middle Yukon to be considered available as part of the food supply of the country.

Late in July king or quinnat salmon are common in the upper river beyond the boundary, being found in the middle and lower waters a month earlier. During the past summer a number of fishermen employed gill nets at Dawson, Northwest Territory, readily taking king salmon of large size. Many fish were found weighing 40 pounds and over, while the prices received for them were so high as to make the business quite profitable. This point is 1,300 miles from the sea. A letter received from Mr. Bernhard Thiele, formerly a seaman on the Fish Commission steamer *Albatross*, and now engaged in salmon fishing on the American side of the boundary, gives the average weight and length of salmon taken by him as follows: Silver salmon, 8½ pounds, 27 inches; dog salmon, 10 pounds, 29 inches. These species were taken in the vicinity of Fort Yukon in August and September. They were more abundant and remained longer than the king salmon. Red salmon and humpbacks are also found during July and August.

Other food-fishes common in the Yukon are whitefish, pike, grayling, trout, suckers, and the ling or lake lawyer (*Lota maculosa*). The last-named reaches a length of 4 or 5 feet. Some of the whitefishes also grow very large, and with the ling are taken chiefly during the winter in traps set under the ice by the natives.

The fish supply of the Yukon is destined to prove of great value to the large mining and trading population now in the middle and upper sections of the valley, especially as there is abundant means of transportation by steamboats during the summer months.

STATISTICS OF CERTAIN FISHERIES OF THE NEW ENGLAND AND MIDDLE ATLANTIC STATES AND THE GREAT LAKES.

The following tables show the yield and value of certain fisheries of Maine, New Hampshire, Massachusetts, New York, New Jersey, Delaware, and the Great Lakes.

The figures relate to the fiscal year 1897.

In comparing these data with those of other years it should be borne in mind that they relate only to the fisheries specified.

Yield by counties of certain fisheries of Maine during the year ending June 30, 1897.

[Persons employed, 5,497; capital invested, $1,173,237.]

Species.	Washington.		Hancock.		Waldo.		Knox.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Alewives, fresh	130,000	$588	24,625	$141			218,600	$2,679
Cod, fresh	83,700	1,236	260,960	4,160			650,970	9,664
Cod, salted	199,132	3,718	2,194,663	47,398			73,000	2,149
Cusk, fresh	4,000	56	58,615	649			238,700	2,631
Cusk, salted	3,912	58	21,795	279			32,500	590
Haddock, fresh	445,900	3,615	327,790	4,333			543,365	6,212
Haddock, salted	75,180	1,009	163,546	2,171			34,200	520
Hake, fresh	82,500	648	653,120	4,144			1,291,148	10,176
Hake, salted	175,135	2,147	819,177	6,862			328,000	3,394
Halibut, fresh	28,500	1,852	45,718	2,689			27,900	1,733
Herring, fresh	25,996,740	43,526	10,198,220	54,164			3,342,000	15,660
Herring, salted			70,000	870			827,400	9,499
Mackerel, fresh			14,000	850			33,000	2,344
Mackerel, salted			29,000	965			300	18
Pollock, fresh	239,000	1,471	81,110	484			148,400	882
Pollock, salted	128,968	1,608	360,884	2,583			24,100	377
Shad, fresh	66,000	1,500						
Shad, salted	20,000	900						
Lobsters	1,651,900	107,198	2,677,217	178,377	28,200	$2,256	2,286,750	162,225
Total	29,330,567	171,130	18,000,440	311,119	28,200	2,256	10,100,333	230,753

Species.	Lincoln.		Sagadahoc.		Kennebec.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Alewives, fresh	544,140	$5,122	119,200	$1,086	3,000	$30
Cod, fresh	541,750	9,630	94,065	1,411		
Cod, salted	1,180,700	29,593				
Cusk, fresh	131,900	1,790				
Cusk, salted	17,400	544				
Haddock, fresh	643,550	10,101	20,000	200		
Haddock, salted	22,000	401				
Hake, fresh	1,186,500	7,883	168,500	1,685		
Hake, salted	155,400	2,751				
Halibut, fresh	14,463	1,310				
Herring, fresh	2,924,780	15,269	44,400	370		
Herring, salted	70,000	350				
Mackerel, fresh	632,100	22,804	36,250	2,899		
Mackerel, salted	473,950	23,544				
Menhaden, salted			50,000	500		
Pollock, fresh	102,036	783	24,300	175		
Pollock, salted	75,500	1,970				
Shad, fresh	329,820	5,284	1,051,160	16,723	26,400	660
Striped bass, fresh			16,350	1,308		
Sturgeon, fresh			14,000	700	300	24
Swordfish, fresh	24,000	1,013				
Lobsters	1,478,250	98,106	81,069	5,605		
Total	10,548,239	238,248	1,719,294	32,662	29,700	714

Yield of certain fisheries of Maine during the year ending June 30, 1897—Continued.

Species.	Cumberland.		York.		Total.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Alewives, fresh	168,000	$1,120	41,520	$322	1,249,085	$11,088
Bluefish, fresh	600	24	240	11	840	35
Cod, fresh	1,728,884	28,043	725,800	13,731	4,086,129	67,875
Cod, salted	44,701	885	8,200	418	3,700,396	84,161
Cusk, fresh	459,851	5,868	97,500	1,065	990,566	12,059
Cusk, salted	13,000	227			88,607	1,698
Haddock, fresh	2,627,846	41,177	879,900	14,838	5,488,351	80,476
Haddock, salted	17,000	170			311,926	4,271
Hake, fresh	1,723,440	11,644	1,199,700	9,401	6,304,908	45,581
Hake, salted	13,000	140	2,000	120	1,492,712	15,414
Halibut, fresh	146,752	9,953	9,049	663	272,382	18,200
Herring, fresh	296,880	2,021	423,000	3,665	43,226,020	134,675
Herring, salted			659,800	7,920	1,627,200	18,639
Mackerel, fresh	429,616	18,671	70,475	5,051	1,215,441	52,619
Mackerel, salted	577,405	25,497			1,080,655	50,024
Menhaden, fresh	3,000	19	66,000	490	69,000	509
Menhaden, salted	30,000	300			80,000	800
Pollock, fresh	417,350	2,626	113,900	1,038	1,126,096	7,459
Pollock, salted	12,500	94	24,100	777	626,052	7,409
Shad, fresh	39,950	659	3,550	68	1,516,880	24,894
Shad, salted	300	14			20,300	914
Striped bass, fresh					16,350	1,308
Sturgeon, fresh			1,400	20	15,700	744
Swordfish, fresh	806,230	33,000	154,696	8,371	984,926	42,384
Lobsters	975,370	65,025	1,122,124	64,290	10,300,880	683,082
Total	10,531,675	247,177	5,602,954	132,259	85,891,402	1,366,318

Yield of certain fisheries of New Hampshire during the year ending June 30, 1897.

[Persons employed, 111; capital invested, $25,600.]

Species.	Pounds.	Value.	Species.	Pounds.	Value.
Alewives, fresh	238,900	$2,947	Mackerel, salted	11,700	$831
Cod, fresh	487,650	8,206	Menhaden, fresh	20,000	150
Cod, salted	1,100	55	Pollock, fresh	156,500	971
Cusk, fresh	63,000	728	Pollock, salted	1,000	30
Haddock, fresh	302,000	5,739	Shad	4,000	120
Hake, fresh	314,000	2,280	Striped bass	1,100	132
Hake, salted	1,000	30	Swordfish	6,250	600
Halibut, fresh	4,550	364	Lobsters	90,300	5,493
Herring, fresh	220,000	2,450			
Mackerel, fresh	75,575	4,509	Total	1,998,625	35,635

Yield by counties of certain fisheries of Massachusetts during the year ending June 30, 1897.

[Persons employed, 9,926; capital invested, $4,572,806.]

Species.	Essex.		Nantucket.		Norfolk.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Alewives, fresh	624,400	$5,886	12,000	$200		
Bluefish	5,100	160	392,000	12,300		
Cod, fresh	23,132,496	391,835	20,000	500		
Cod, salted	32,596,965	721,410	450,000	11,500		
Cusk, fresh	2,015,870	23,785				
Cusk, salted	315,250	6,950				
Haddock, fresh	23,362,611	352,826	112,500	2,250		
Hake, fresh	7,306,844	46,076				
Hake, salted	13,000	121				
Halibut, fresh	8,743,226	566,794				
Halibut, salted	1,178,795	46,701				
Halibut fins	108,200	5,510				
Herring, fresh	5,448,260	33,261				
Herring, salted	67,000	929				
Mackerel, fresh	1,677,794	110,108	11,200	772		
Mackerel, salted	6,511,300	337,135				
Menhaden	139,000	930				
Pollock, fresh	1,962,334	11,409	10,000	200		
Pollock, salted	10,200	201				
Shad	700	47				
Swordfish	279,000	9,949	6,300	252		
Lobsters	416,986	38,046	54,800	3,836	94,060	$7,525
Total	115,915,331	2,710,069	1,068,800	31,810	94,060	7,525

Yield of certain fisheries of Massachusetts during the year ending June 30, 1897—Cont'd.

Species.	Barnstable.		Bristol.		Dukes.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Alewives, fresh	828,369	$9,860	681,500	$7,549	579,310	$5,979
Alewives, salted	918,325	13,697	394,000	4,925		
Bluefish	139,987	6,880	5,600	256	20,948	884
Cod, fresh	6,922,212	87,241	58,400	1,698	61,925	1,306
Cod, salted	2,904,116	50,513	470,110	11,603	45,000	1,500
Cusk, fresh	345,600	3,791				
Haddock, fresh	1,376,300	23,815				
Haddock, salted	1,120	18	43,000	430		
Hake, fresh	1,366,200	7,304				
Hake, salted			53,000	530		
Halibut, fresh	521,150	49,702				
Herring, fresh	4,299,417	23,485	30,000	300		
Mackerel, fresh	1,683,066	64,256	63,200	3,175	300,250	15,800
Mackerel, salted	837,800	39,235	125,000	4,355	2,000	100
Menhaden	681,960	2,487	140,000	700	144,750	663
Pollock, fresh	4,972,000	16,482				
Pollock, salted	102,900	1,078				
Shad	15,534	507	13,010	730	2,575	182
Spanish mackerel			220	66		
Squeteague	58,334	1,343	392,000	11,760	647,612	17,607
Striped bass	4,606	507	5,100	562	2,630	291
Sturgeon	12,632	421			5,100	280
Swordfish	17,060	538			8,750	306
Lobsters	227,450	15,821	120,364	9,740	295,179	16,742
Oysters	303,604	68,446	35,000	2,500		
Sperm oil	547,388	30,290	1,588,890	95,336		
Whale oil			96,083	4,484		
Blackfish oil	390	18	75	30		
Bone			9,800	34,300		
Ambergris			2	400		
Total	28,187,520	517,735	4,324,354	195,429	2,116,029	61,640

Species.	Plymouth.		Suffolk.		Total.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Alewives, fresh	84,800	$864			2,810,379	$30,338
Alewives, salted					1,312,325	18,622
Bluefish					563,635	20,480
Cod, fresh	213,600	4,236	3,772,051	$69,429	34,180,684	556,245
Cod, salted	19,200	700	146,172	3,043	35,731,563	800,269
Cusk, fresh			200,500	2,345	2,561,970	29,921
Cusk, salted			1,000	13	316,250	6,963
Haddock, fresh	142,800	2,685	8,061,700	149,842	33,055,911	531,418
Haddock, salted			6,000	90	50,120	538
Hake, fresh	12,400	76	2,256,900	15,540	10,942,344	68,996
Hake, salted			9,435	109	75,435	760
Halibut, fresh			130,824	13,577	9,395,200	630,073
Halibut, salted					1,178,795	46,701
Halibut fins					108,200	5,510
Herring, fresh	44,000	328	560,000	3,900	10,381,677	61,274
Herring, salted					67,000	929
Mackerel, fresh	19,200	1,180	47,368	3,433	3,802,078	198,724
Mackerel, salted			363,200	16,345	7,839,300	397,170
Menhaden					1,105,710	4,780
Pollock, fresh	1,000	5	158,500	1,135	7,103,834	29,231
Pollock, salted					113,100	1,279
Shad					31,819	1,466
Spanish mackerel					220	66
Squeteague					1,097,946	30,710
Striped bass					12,336	1,360
Sturgeon					17,732	701
Swordfish	134,800	12,804	43,725	2,086	489,635	25,935
Lobsters	491,188	35,338	389,475	30,282	2,089,502	157,330
Oysters					338,604	70,946
Sperm oil			552,780	31,352	2,689,058	156,978
Whale oil			13,455	592	109,538	5,076
Blackfish oil					465	48
Bone			600	1,380	10,400	35,680
Ambergris			12¾	2,285	14¾	2,685
Total	1,162,988	58,216	16,713,697¾	346,778	169,582,779¾	3,929,202

Yield of certain fisheries of New York during the year ending June 30, 1897.

[Persons employed, 5,790; capital invested, $1,452,451.]

Counties.	Alewives.		Bluefish.		Cod.		Haddock.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Albany	61,600	$853						
Columbia	84,640	1,156						
Dutchess	131,326	1,320						
Greene	232,640	3,019						
Kings	2,000	20						
New York			6,669,467	$233,464	1,091,520	$32,795		
Orange	13,600	136						
Queens	5,144	115	799,915	34,251	179,800	6,182		
Rensselaer	89,600	1,080						
Suffolk	54,210	840	2,911,259	106,024	355,190	9,206	21,050	$611
Ulster	227,200	2,297						
Westchester	2,320	29						
Total	904,280	10,865	10,380,641	373,739	1,626,510	48,183	21,050	611

Counties.	Hake.		Mackerel.		Menhaden.		Shad.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Albany							238	$13
Columbia							43,275	2,007
Dutchess							321,767	11,068
Greene							45,731	2,221
Kings					15,669,600	$39,174	169,919	6,290
Orange							76,020	3,043
Putnam							14,210	554
Queens			450	$38			7,126	742
Rensselaer							168	10
Richmond							144,480	5,148
Rockland							201,583	10,750
Suffolk	1,120	$22	145,354	6,350	55,371,990	141,318	15,750	930
Ulster							502,992	16,367
Westchester							198,907	9,918
Total	1,120	22	145,804	6,388	71,041,590	180,492	1,742,166	69,061

Counties.	Spanish mackerel.		Squeteague.		Striped bass.		Sturgeon.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Albany					380	$54		
Dutchess							29,767	$1,710
Greene							3,320	223
Kings	4,000	$120	2,000	$60	1,600	144		
Orange							21,050	1,180
Putnam							2,470	132
Queens	4,060	710	515,580	14,658	39,797	4,879		
Rensselaer					300	42		
Suffolk	6,905	1,206	1,931,188	49,817	57,200	6,869	315,510	15,177
Ulster							2,870	154
Westchester					5,520	655	18,150	910
Total	14,965	2,036	2,448,768	64,535	104,797	12,643	393,137	19,486

Counties.	Lobsters.		Oysters.		Total.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Albany					62,218	$920
Columbia					127,915	3,163
Dutchess					482,860	14,098
Greene					281,691	5,463
Kings	9,860	$1,130	2,675,078	$393,850	18,534,057	440,788
New York	102,355	7,973	428,400	66,150	8,291,742	340,382
Orange					110,670	4,359
Putnam					16,680	686
Queens			4,184,047	580,723	5,735,919	642,298
Rensselaer					90,068	1,132
Richmond			2,706,375	349,655	2,850,855	354,803
Rockland					201,583	10,750
Suffolk	13,280	1,264	5,217,625	743,940	66,417,631	1,083,574
Ulster					733,062	18,818
Westchester	5,115	546	305,585	33,145	535,597	45,203
Total	130,610	10,913	15,517,110	2,167,463	104,472,548	2,966,437

Yield by counties of certain fisheries of New Jersey during the year ending June 30, 1897.

[Persons employed, 9,726; capital invested, $1,454,022.]

Species.	Atlantic.		Bergen.		Burlington.		Camden.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Alewives	30,000	$480			348,800	$2,170	112,400	$544
Bluefish	17,900	957						
Shad	1,085	64	454,391	$17,103	1,095,549	31,555	1,393,385	35,760
Squeteague	794,285	31,180			39,335	1,200		
Striped bass	25,840	4,273			48,400	6,433	2,900	321
Oysters, market	982,520	154,927			233,800	26,052	409,626	71,958
Oysters, seed and shells	283,500	10,509			44,800	1,920	777,700	11,346
Total	2,135,130	202,390	454,391	17,103	1,810,684	69,330	2,696,011	119,929

Species.	Cape May.		Cumberland.		Gloucester.		Hudson.		Hunterdon.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds	Value.	Pounds	Value.
Alewives	18,500	$182	18,000	$146	96,200	$518				
Bluefish	268,650	8,330								
Cod	38,000	831								
Mackerel	200	16								
Menhaden	65,000	360								
Shad	1,127	65	784,714	25,620	1,228,360	31,983	393,669	$13,203	160,202	$8,137
Spanish mackerel	465	72								
Squeteague	1,025,850	26,084					1,600	110		
Striped bass	46,120	5,308	14,200	1,420	3,400	340	1,200	72	1,910	232
Sturgeon	94,495	3,629	888,200	32,705						
Oysters, market	471,842	68,330	4,084,066	704,361			18,480	3,025		
Oysters, seed and shells	285,390	6,879	9,663,080	155,869			157,500	10,650		
Lobsters							8,500	595		
Total	2,315,639	120,086	15,452,260	920,121	1,327,960	32,841	580,949	27,655	162,112	8,369

Species.	Mercer.		Middlesex.		Monmouth.		Ocean.		Salem.	
	Pounds	Value	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Alewives	29,600	$184	1,800	$20	46,600	$705	338,600	$2,990	23,200	$124
Bluefish			1,000	52	5,240,955	117,537	810,610	27,287		
Cod					1,708,055	24,534	84,450	2,376		
Haddock					2,600	30	1,000	25		
Mackerel					13,210	1,228	1,000	116		
Menhaden			800,000	1,400	15,954,600	52,484	33,200	214		
Shad	195,440	8,906	22,540	1,385	215,737	11,048	9,030	403	4,648,056	132,335
Spanish mack'l					66,660	7,329	12,300	1,452		
Squeteague			2,920	146	13,002,425	179,921	896,150	23,761		
Striped bass	2,450	279	2,980	406	33,260	3,776	58,680	9,656	4,700	470
Sturgeon					37,155	1,377	4,200	170	732,735	25,305
Oysters, market			412,300	61,780	1,084,636	164,493	1,141,035	131,300		
Oysters, seed and shells			112,000	5,600	60,200	3,240	466,970	19,796		
Lobsters					65,480	5,182	5,250	420		
Total	227,490	9,369	1,355,540	70,789	37,531,573	572,884	3,862,475	219,966	5,408,691	158,234

Species.	Sussex.		Union.		Warren.		Total.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Alewives							1,063,700	$8,063
Bluefish							6,339,115	154,163
Cod							1,830,505	27,741
Haddock							3,600	55
Mackerel							14,410	1,360
Menhaden							16,852,800	54,458
Shad	6,650	$405			43,470	$2,222	10,653,405	320,194
Spanish mackerel							79,425	8,853
Squeteague							15,762,565	262,402
Striped bass							246,040	32,986
Sturgeon							1,756,785	63,186
Oysters, market			9,555	$1,280			8,847,860	1,387,506
Oysters, seed and shell.			299,600	23,715			12,150,740	249,524
Lobsters							79,230	6,197
Total	6,650	405	309,155	24,995	43,470	2,222	75,680,180	2,576,688

Yield by counties of certain fisheries of Delaware during the year ending June 30, 1897.

[Persons employed, 1,464; capital invested, $121,020.]

Species.	Kent.		Newcastle.		Sussex.		Total.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Alewives	14,520	$174	235,200	$973	494,540	$4,177	744,260	$5,324
Shad	198,594	8,051	1,162,707	38,002	111,689	5,702	1,472,990	51,755
Squeteague	900,050	12,595			45,400	1,092	945,450	13,687
Striped bass	8,557	1,032	5,340	650	16,205	2,576	30,102	4,258
Sturgeon	194,180	6,128	486,770	16,787			680,950	22,915
Oysters, market	372,232	24,635			70,840	4,227	443,072	28,862
Oysters, seed	260,400	4,707					260,400	4,707
Total	1,948,533	57,322	1,890,017	56,412	738,674	17,774	4,577,224	131,508

Yield of certain fisheries of Lake Superior during the year ending June 30, 1897.

[Persons employed, 658; capital invested, $329,303.]

States and counties.	Herring.		Pike.		Sturgeon.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Michigan:						
Chippewa			4,025	$166	6,292	$252
Houghton	63,815	$957			1,500	45
Keweenaw	54,792	513				
Marquette	44,050	679				
Ontonagon					250	9
Total	162,657	2,149	4,025	166	8,042	306
Minnesota:						
Cook	29,420	282				
Lake	153,111	2,162				
St. Louis	37,687	565				
Total	220,218	3,009				
Wisconsin:						
Bayfield	94,160	565	260	13		
Grand total	477,035	5,723	4,285	179	8,042	306

States and counties.	Trout.		Whitefish.		Total.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Michigan:						
Alger	48,048	$1,922	32,925	$1,315	80,973	$3,237
Baraga	67,875	2,715	46,953	1,878	114,828	4,593
Chippewa	592,142	20,329	482,370	16,874	1,084,829	37,621
Houghton	147,100	5,884	131,000	5,240	343,415	12,126
Keweenaw	697,662	18,974	124,206	3,946	876,660	23,433
Luce	4,746	185	12,340	618	17,086	803
Marquette	426,239	16,470	147,117	5,894	617,406	23,043
Ontonagon	157,155	6,287	267,830	8,413	425,235	14,709
Total	2,140,967	72,766	1,244,741	44,178	3,560,432	119,565
Minnesota:						
Cook	211,715	5,759	14,323	446	255,458	6,487
Lake	160,387	4,883	8,229	250	321,727	7,295
St. Louis	22,134	719	8,284	208	68,105	1,492
Total	394,236	11,361	30,836	904	645,290	15,274
Wisconsin:						
Ashland	256,466	9,350	58,908	2,000	315,374	11,350
Bayfield	523,747	17,270	102,940	2,707	721,107	20,555
Total	780,213	26,620	161,848	4,707	1,036,481	31,905
Grand total	3,315,416	110,747	1,437,425	49,789	5,242,203	166,744

Yield of certain fisheries of Lake Michigan during the year ending June 30, 1897.

[Persons employed, 2,289; capital invested, $915,381.]

States and counties.	Bass.		Herring.		Perch.		Pike and pike perch.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Michigan:								
Allegan	1,000	$50			61,600	$2,156		
Berrien			199,642	$3,746				
Delta			31,747	379	20,840	313	288,789	$9,297
Mackinac	1,564	86	66,247	881	3,200	49	8,460	285
Mason			6,480	135				
Menominee	5,000	300	4,714,390	27,767	120,000	1,800	60,000	1,500
Muskegon	290	23	87,180	1,453	272	11		
Oceana	150	10	24,600	450	500	8		
Ottawa	868	34	1,109,763	19,314	19,076	627	244	12
Total	8,872	503	6,240,049	54,125	225,488	4,964	357,493	11,094
Indiana:								
Lake			155,650	2,065	52,900	1,558		
Laporte			234,655	4,507	9,300	279		
Total			390,305	6,572	62,200	1,837		
Illinois:								
Cook			15,000	240	865,000	26,080		
Lake			103,266	1,921	26,470	529		
Total			118,266	2,161	891,470	26,609		
Wisconsin:								
Brown	25,564	1,278	892,373	4,895	1,422,136	19,099	300,844	9,339
Door	2,156	107	4,372,766	27,496	155,419	1,942	21,972	760
Kenosha			515,139	8,585	20,247	608		
Kewaunee			102,000	690				
Manitowoc			1,392,643	21,703	2,200	76		
Marinette			357,000	2,165	15,500	310	16,000	450
Milwaukee			1,303,632	22,069				
Oconto			4,136,600	25,181	241,000	3,082	130,000	3,885
Ozaukee			706,381	9,702	4,300	135		
Racine			21,600	360				
Sheboygan			1,564,338	25,239	12,900	405		
Total	27,720	1,385	15,364,472	148,085	1,873,702	25,657	468,816	14,434
Grand total	36,592	1,888	22,113,092	210,943	3,052,860	59,067	826,309	25,528

States and counties.	Sturgeon.		Trout.		Whitefish, common.		Whitefish, bluefin.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Michigan:								
Allegan	6,250	$350			3,500	$210		
Antrim			21,425	$600	44,434	1,750		
Benzie			225,742	7,432	114,100	5,495		
Berrien	753	37	311,377	14,718	8,565	361		
Charlevoix			1,504,630	38,514	1,100,237	39,094	150,137	$3,229
Delta	20,277	752	207,011	6,112	153,721	5,918		
Emmet			401,174	10,871	153,382	5,535	680	14
Grand Traverse			10,750	265	33,760	1,200		
Leelanaw			378,521	8,326	166,886	5,579	8,412	129
Mackinac	8,230	264	261,852	8,219	481,046	14,687		
Manistee			152,868	4 484			80,862	2,092
Mason			116,946	4,391	4,354	190	18,986	316
Menominee			50,000	1,200	12,000	400		
Muskegon	3,410	154	24,731	719	3,570	120		
Oceana	4,200	221	17,875	550	5,350	230		
Ottawa	3,464	160	186,129	6,350	900	38		
Schoolcraft	1,200	45	479,101	13,760	317,095	11,073		
Total	47,784	1,983	4,350,132	126,511	2,602,900	91,880	259,077	5,780

Yield of certain fisheries of Lake Michigan during the year ending June 30, 1897—Cont'd.

States and counties.	Sturgeon.		Trout.		Whitefish, common.		Whitefish, bluefin.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Indiana:								
Lake	14,760	$666			3,360	$170		
Laporte	8,288	560	20,824	$916	25,200	1,575		
Total	23,048	1,226	20,824	916	28,560	1,745		
Illinois:								
Lake			219,266	9,227	11,200	384		
Wisconsin:								
Brown	26,848	1,075	87,668	2,467	12,032	186		
Door	19,312	772	1,140,045	32,851	556,085	12,280		
Kenosha			235,536	8,525				
Kewaunee			382,155	13,173	295,516	4,862		
Manitowoc			778,955	23,709	4,475	181	228,902	$3,582
Marinette	625	26	15,000	480				
Milwaukee			952,672	38,026				
Oconto	5,250	210	5,000	140	250	10		
Ozaukee	1,406	90	303,741	9,232	4,500	225		
Racine			281,250	11,250				
Sheboygan	4,219	270	529,206	20,611	13,500	660	157,812	2,625
Total	57,660	2,443	4,711,228	160,464	886,358	18,404	386,714	6,207
Grand total	128,492	5,652	9,301,450	297,118	3,529,018	112,413	645,791	11,987

SUMMARY.

States and counties.	Pounds.	Value.	States and counties.	Pounds.	Value.
Michigan:			**Illinois:**		
Allegan	72,350	$2,766	Cook	880,000	$26,320
Antrim	65,859	2,350	Lake	360,202	12,061
Benzie	339,842	12,927			
Berrien	520,337	18,862	Total	1,240,202	38,381
Charlevoix	2,755,004	80,837			
Delta	722,385	22,771	**Wisconsin:**		
Emmet	555,236	16,420	Brown	2,767,465	38,339
Grand Traverse	44,510	1,465	Door	6,267,755	76,208
Leelanaw	553,819	14,034	Kenosha	770,922	17,718
Mackinac	830,599	24,471	Kewaunee	779,671	18,725
Manistee	233,730	6,576	Manitowoc	2,407,175	49,251
Mason	146,766	5,032	Marinette	404,125	3,431
Menominee	4,961,390	32,967	Milwaukee	2,256,304	60,095
Muskegon	119,453	2,480	Oconto	4,518,100	32,508
Oceana	52,675	1,469	Ozaukee	1,020,328	19,384
Ottawa	1,320,444	26,535	Racine	302,850	11,610
Schoolcraft	797,396	24,878	Sheboygan	2,281,975	49,810
Total	14,091,795	296,840	Total	23,776,670	377,079
Indiana:			Grand total	39,633,604	724,596
Lake	226,670	4,459			
Laporte	298,267	7,837			
Total	524,937	12,296			

Yield of certain fisheries of Lake St. Clair, St. Clair River, and Detroit River during the year ending June 30, 1897.

[Persons employed, 218; capital invested, $4,546.]

State and counties.	Apparatus.	Herring.		Sturgeon.		Perch.	
		Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Michigan:							
Wayne	Pound nets	1,773	$44	1,440	$76		
St. Clair	Seines			5,600	210	4,200	$106
St. Clair	Lines			4,830	130	1,000	25
Wayne	...do			28,000	2,000		
Total				32,830	2,130	1,000	25
Grand total		1,773	44	39,870	2,416	5,200	131

State and counties.	Apparatus.	Wall-eyed pike.		Whitefish.		Total.	
		Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Michigan:							
Wayne	Pound nets	6,710	$335	527	$32	10,450	$487
St. Clair	Seines	88,000	3,660			97,800	3,976
St. Clair	Lines	217,750	7,494			223,580	7,649
Wayne	...do					28,000	2,000
Total		217,750	7,494			251,580	9,649
Grand total		312,460	11,489	527	32	359,830	14,112

Yield of certain fisheries of Lake Huron during the year ending June 30, 1897.

[Persons employed, 908; capital invested, $238,038.]

State and counties.	Bass.		Herring.		Sturgeon.		Perch.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Michigan:								
Chippewa	721	$40	9,450	$94	3,655	$97	2,692	$30
Mackinac			4,420	46			400	6
Cheboygan and Presque Isle	1,232	68	46,487	703	7,725	234	2,738	41
Alpena			92,056	681	1,642	49	1,019	14
Iosco			23,800	1,400	3,200	120	12,000	120
Arenac, Bay, and Tuscola	4,940	99	4,191,039	24,775	2,785	104	920,587	9,206
Huron			2,377,810	20,411	12,069	464	280,794	3,500
Sanilac			279,784	1,824	1,810	88	2,500	70
St. Clair			157,683	946	8,478	261	764	14
Total	6,893	207	7,182,529	50,880	41,364	1,417	1,223,494	13,001

State and counties.	Wall-eyed pike.		Trout.		Whitefish.		Total.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Val.
Michigan:								
Chippewa	69,031	$2,161	135,757	$3,700	273,438	$8,104	494,744	$14,226
Mackinac			39,608	1,574	37,700	1,212	82,128	2,838
Cheboygan and Presque Isle	9,840	380	288,242	9,523	360,240	12,232	716,504	23,181
Alpena	8,736	349	632,527	20,156	316,481	10,852	1,052,461	32,191
Iosco	16,000	640	66,250	2,060	47,830	1,640	169,080	5,980
Arenac, Bay, and Tuscola	760,706	26,625	27,137	934	198,261	7,210	6,105,455	68,953
Huron	318,250	11,832	106,979	3,649	125,341	5,298	3,221,243	45,154
Sanilac	5,450	258	7,822	235	29,946	1,125	327,312	3,600
St. Clair	42,864	1,310	3,190	102	2,330	100	215,309	2,733
Total	1,230,877	43,555	1,307,512	41,933	1,391,567	47,773	12,384,236	198,766

Yield of certain fisheries of Lake Erie during the year ending June 30, 1897.

[Number of persons employed, 1,458; investment in vessels and other property, $964,430.]

States and counties.	Bass.		Herring.		Perch.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
New York:						
Erie	....	....	130,000	$1,525	55,000	$625
Chautauqua	8,000	$180	768,010	7,535	40,172	424
Total	8,000	180	898,010	9,060	95,172	1,049
Pennsylvania:						
Erie	10,052	201	6,940,932	63,547	407,278	4,888
Ohio:						
Ashtabula	....	....	1,238,760	10,388	170,600	1,716
Lake	....	....	500,000	5,000	37,000	370
Cuyahoga	2,189	58	5,001,396	60,643	715,277	7,600
Lorain	20,406	507	579,106	6,508	178,030	2,020
Erie	11,548	570	3,280,269	38,859	925,331	11,332
Ottawa	75,020	4,038	422,981	5,304	477,908	4,779
Lucas	1,096	33	698,199	6,982	99,531	995
Total	110,259	5,206	11,720,711	133,684	2,603,677	28,812
Michigan:						
Monroe	4,772	141	78,636	820	99,265	992
Grand total	133,083	5,728	19,638,289	207,111	3,205,392	35,741

States and counties.	Wall-eyed pike.		Blue pike.		Saugers.		Sturgeon.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
New York:								
Erie	6,600	$200	95,000	$2,350	....	....	80,000	$2,075
Chautauqua	12,000	720	301,006	5,310	....	....	52,644	1,721
Total	18,600	920	396,006	7,660	....	....	132,644	3,796
Pennsylvania:								
Erie	27,032	1,417	2,668,778	56,927	....	....	35,414	1,075
Ohio:								
Ashtabula	....	....	276,900	4,361	....	....	30,800	1,078
Lake	....	....	246,000	4,870	....	....	8,290	249
Cuyahoga	30,821	1,433	857,660	16,635	237,266	$3,335	5,192	176
Lorain	22,045	1,073	323,776	6,444	244,888	4,747	19,594	784
Erie	271,943	11,356	82,417	1,653	2,365,180	36,882	11,060	531
Ottawa	295,472	9,157	....	....	1,218,417	15,332	8,540	42
Lucas	444,802	14,925	....	....	740,036	9,186	210	13
Total	1,065,083	37,944	1,786,753	33,963	4,805,787	69,482	83,686	2,873
Michigan:								
Monroe	364,768	12,163	....	....	122,433	1,582	7,628	469
Grand total	1,475,483	52,444	4,851,537	98,550	4,928,220	71,064	259,372	8,213

States and counties.	Trout.		Whitefish.		Total.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
New York:						
Erie	....	....	18,000	$1,000	384,600	$7,775
Chautauqua	36,482	$1,478	39,825	2,390	1,258,139	19,758
Total	36,482	1,478	57,825	3,390	1,642,739	27,533
Pennsylvania:						
Erie	184	10	169,124	9,966	10,258,794	138,031
Ohio:						
Ashtabula	....	....	8,300	498	1,725,360	18,041
Lake	....	....	61,000	3,350	852,290	13,839
Cuyahoga	30,000	750	62,320	3,811	6,942,121	94,441
Lorain	....	....	51,926	3,515	1,439,771	25,598
Erie	....	....	185,035	10,987	7,132,783	112,170
Ottawa	....	....	32,020	2,017	2,530,358	40,669
Lucas	....	....	8,349	501	1,992,223	32,635
Total	30,000	750	408,950	24,679	22,614,906	337,393
Michigan:						
Monroe	....	....	54,007	2,680	731,509	18,847
Grand total	66,666	2,238	689,906	40,715	35,247,948	521,804

This table includes 30,000 pounds of trout, worth $750, and 9,300 pounds of whitefish, worth $400, caught in Lake Huron by a vessel owned at Cleveland, Ohio.

REPORT

ON

MACKEREL INVESTIGATIONS IN 1897.

BY

J. PERCY MOORE.

REPORT ON MACKEREL INVESTIGATIONS IN 1897.

By J. Percy Moore.

INTRODUCTION.

The almost unparalleled scarcity of mackerel in our waters during the last decade, and the consequent loss to our fishermen, having given rise to the fear of a permanent decrease in numbers of this excellent fish, it has become incumbent upon the United States Fish Commission to determine the cause of the decrease and, if possible, to augment the supply. Similar periods of scarcity, but of shorter duration, are recorded from time to time in the history of the mackerel fishery, and have hitherto been followed by times of greater plenty. This well-known fact should lead us to hope that the present conditions are only temporary, but it is none the less important to determine, and if possible to overcome, the disturbing cause, to the end that a constant and certain supply of this capricious wanderer may be had.

Why the mackerel supply is thus subject to periodical wax and wane is unknown. There are no certain data upon which to venture a solution of the problem. Are their numbers depleted by disease? There is no evidence that the mackerel is subject to any serious infectious disease. Is the decrease due to a period of lowered fertility, of less or greater duration? Here again we lack facts. We know but little to what extent the biological and physical conditions of the sea have varied, nor yet how variations in these factors affect the vitality and habits of the mackerel. There may have been no actual diminution in the propagating capacity of the fish, but some condition peculiarly detrimental to the development of the eggs and embryos may have existed, causing their consequent destruction on a large scale. Has there been a real or only an apparent decrease due to migrations of the fish from our waters to other parts of the ocean? This view, most frequently accepted as explaining the fact, has little to support it, and is a mere guess founded on the known wandering habits of the mackerel.

For several years past the Fish Commission has attempted to overcome the deficiency by propagating the mackerel artificially. So far as any practical results are concerned, the attempt has been unsuccessful. Briefly stated, the difficulties have been two, namely, the number of eggs obtained has been entirely inadequate, and the proportion hatched in most cases has been low.

The present report contains a statement of the results attained in the course of a brief study of this work of mackerel propagation during the season of 1897. The investigation was begun in early June at

Woods Hole, and was continued from June 25 to July 27 on board the steamer *Fish Hawk*, in Casco Bay, Maine. During August the material and data gathered were worked over at Woods Hole. At Woods Hole the local fisheries were watched closely in order to determine the advent of spawning schools, and numerous samples of male and female fish were examined in order to secure material for a study of the maturing ova and spermatozoa. Two small lots of eggs, aggregating 110,000, were brought to the station and kept under observation during their whole period of development.

At Casco Bay the season proved peculiarly unfavorable for the investigation, which could not be brought to completion with the limited time and facilities at our disposal. Only a few over 1,000,000 eggs were taken, the first on June 25, the last on July 8. Although this number was sufficient to permit a study of the general history of development and the preservation of material for a more complete review of the embryology, it proved to be entirely inadequate for purposes of experimentation, which, in order to yield conclusive results and eliminate all doubtful factors, requires extensive checks. The impossibility of applying these, and the necessity of limiting the experiments to but one series of those proposed, render this part of the work less valuable than it otherwise might have proved.

For a discussion of the sources of supply of eggs and the conditions under which they were taken, I refer to the reports of Mr. Locke for Woods Hole, and Lieutenant Swift for operations of the *Fish Hawk*.

The results of the investigations may best be considered under the three heads or groups into which they were organized, namely, (1) embryology, (2) surface towings, and (3) experiments.

1. RESULTS OF EMBRYOLOGICAL STUDIES.

Under this head will be considered the morphology of the reproductive organs, the general history of development, and observations on the conditions which affect it. In the present connection only a general account showing the similarity in development of the mackerel to other fishes producing similar pelagic eggs (the cod, Spanish mackerel, sea bass, etc.) need be given, prominence being given to only those features which are of most interest to fish-culturists.

A careful study of the rate of growth of the mackerel leads to the conclusion that maturity is reached at the age of three years, at which time the female is 12 to 14 inches long and the male somewhat smaller. In the region included between Cape Cod and Block Island the spawning season extends from the middle of May to about the 1st of July; but few spawning fish are taken after June 15. At Casco Bay the season probably begins and ends, respectively, about two weeks later, the majority of the fish spawning before the 25th of June. From the time of our arrival a systematic record was kept of the condition of ovaries and testes of as many fish as could be obtained for examination. Very nearly all were partly or entirely spent, and the proportion of fully spent fish increased toward the end of the season, though

occasionally a spawning or even immature ovary was met with. It is worthy of remark that, even in the same run, fish in very different conditions of maturity were found. Most of them were nearly or quite through spawning; a smaller number might be immature, and for some unknown reason would probably fail to ripen their eggs this season, while a still smaller number would be spawning fish. In nearly all cases the number of males was greater than the number of females. The fishermen were almost unanimous in stating that a run of spawning fish much more productive than any which we encountered had passed into Casco Bay about two weeks previous to our arrival.

If an ovary of a mackerel be examined just previous to the spawning season, it will be found to contain ova of three sizes or generations. Constituting the bulk of its lamellæ are large, opaque ova measuring from 0.35 mm. to 0.55 mm. (say about 0.02 inch) in diameter. These have large, ill-defined nuclei, well-developed egg-membranes and egg-follicles, protoplasm filled with yolk-spherules and a number of minute oil-droplets, which latter are scattered in the smaller, but more or less closely aggregated in the larger of these ova. The opaque ova just described are destined to produce the mature eggs of the approaching spawning season. Packed between them are smaller ova of two sizes. The larger ones measure about 0.12 mm. in diameter, are about as numerous as the large, opaque ova, and are destined to produce a crop of eggs a year hence. The smallest measure about 0.04 mm. in diameter, are very numerous, aggregated in clusters, have large and distinct nuclei, no follicles, and retain the character of simple cells. From these future crops of ova will arise.

As the spawning season approaches, part of the opaque ova increase rapidly in size. The yolk-corpuscles, to which the opacity was due, pass into solution, and as a consequence the yolk becomes more and more transparent and of a pale amber color. The oil-droplets coalesce into two or three larger drops and finally into a single sphere, which is free to move about in the now fluid yolk. The nucleus has, meantime, become invisible. Such ova are ready for extrusion and the final processes of maturation. Owing to these changes the ovary as a whole has increased greatly in bulk, and becomes spotted all over, both externally and on the internal laminæ, with translucent spots, due to aggregations of the clear eggs. Unlike some fishes (those generally of sluggish habit or bottom-livers) the mackerel matures only a portion of the generation of eggs at one time. Thus is obviated any undue enlargement of the ovary, which would cause the body walls to protrude and doubtless obstruct the movements of the fish, a result which might be particularly serious to an active pelagic species like the mackerel. The number of ova produced at one time is seldom more than 50,000 and is frequently much less, but the aggregate number matured in one season by a female of average size is several hundred thousands.

All of the evidence which could be gathered from examinations of the ovaries of numerous fishes captured at different hours of the day seems to indicate that the common mackerel, like the Spanish mackerel

and many other fishes, is a night spawner. Although development of the ova proceeds in all parts of the ovary at once, the process is at first more rapid in the posterior (external) end, which consequently becomes spent while the ova production is still active at the anterior (internal) end. The transparent eggs, or more correctly "egg mother-cells," now rupture the follicular membranes which envelop them and are dehisced into the ovarian cavity, where they lie among the ova-bearing laminæ bathed in a small quantity of serous fluid. They are slightly smaller and more irregular in shape than the fertilized ova, owing to the somewhat flaccid, wrinkled state of the egg membrane and the mutual pressure to which they are subjected. When first dehisced into the ovarian cavity they are rather opaque, owing to the presence of numerous minute spherules in and beneath the protoplasmic layer which envelops the fluid yolk. As these spherules are gradually absorbed, the egg mother-cells become more and more transparent; but the last granules do not finally disappear until the egg is extruded from the oviduct and feels the stimulus of contact with sea water. Under these circumstances the least opaque eggs immediately assume a crystalline transparency; the more opaque and less mature ones clear up more slowly, but usually as completely, and the process is probably facilitated in this, as in the case of the Spanish mackerel, by the presence of spermatozoa. Immediately upon contact with the sea water, whether or not spermatozoa be present, the egg mother-cell absorbs water and assumes a perfectly spherical shape, the egg membrane becomes tense, while the processes attending maturation ensue.

The egg now resembles the well-known pelagic ova of the Spanish mackerel, sea bass, and other fishes. It is at first perfectly spherical and varies considerably in size. The average diameter of a large number of eggs from all sources procurable is 1.25 mm., but even from the same female they have varied from 1.16 to 1.29 mm., and it was also found that all of the eggs produced by a particular female were sometimes larger, sometimes smaller, than the average. Thus, all the eggs of the two lots studied at Woods Hole which were measured averaged 1.15 mm., and the individual eggs varied but slightly from this average. On the other hand, all of the Casco Bay females produced eggs of larger size, at the same time presenting a greater range of variation. The horny, transparent, vitelline membrane which surrounds the egg is of uniform thinness except at a small circular area which, perhaps owing to its greater weight, always gravitates to the lowermost pole of the floating egg. This is a micropylar thickening, a crater-like elevation projecting inward in contact with the vitellus. A funnel shaped depression exists in its outer surface and extends about half way through, from which point it is continued to the inner surface by an exceedingly narrow and perfectly straight canal, the micropyle, through which the spermatozoan finds its way to fertilize the ovum. Exceedingly delicate canals perforate the whole region of the micropylar thickening and doubtless afford a means of interchange of water bearing the respiratory gases. Similar but much smaller and

less numerous perforations exist in all parts of the vitelline membrane, but are difficult to demonstrate until during the later stages of development, when the membrane becomes more brittle and the perforations perhaps larger.

The egg proper, or vitellus, consists of a vesicle-like skin of protoplasm, faintly granular, of a pale brown color and of uniform thickness throughout, distended by a perfectly fluid transparent yolk, in which there are no structural elements observable, except occasionally a few aggregations of spherical bodies attached here and there to the inner surface of the protoplasmic pellicle. Floating freely about within the protoplasmic skin and, because of its lower specific gravity, always rising to the highest point in the egg, is a beautifully clear and perfectly spherical oil-drop, by virtue of the presence of which the egg is buoyant. The oil-drop also is enveloped by a delicate protoplasmic sheath, which is at first of uniform thickness and always quite distinct from the protoplasm enveloping the yolk. The oil-drop is of unusually large size, but varies both absolutely and relatively to the size of the egg to a considerable degree. Its average size is 0.28 mm. Its color also varies. Sometimes it is perfectly colorless; sometimes, and more frequently, of a pale amber, or even of a pinkish tint. And this variation may be observed in eggs taken from the same female. The reason for this is not apparent, but it was noticed that colorless oil-drops occur most frequently in eggs of the smaller sizes. Perhaps both may indicate a condition of impaired vitality, though this could not be proved by the results of the further course of development.

Owing to the unfavorable circumstances under which the mackerel eggs were taken, I was unable to study the maturation processes in the living egg, but material was preserved for a future study of this phase of development. There is no reason to doubt, however, that the process is essentially similar in this and other pelagic eggs, and I refer to my report on the Spanish mackerel and to the papers of Agassiz and Whitman on the cunner, and of Ryder on the cod, for some observations on these phenomena. The process consists essentially in the elimination from the egg mother-cell of a part of its nuclear substance, without which it seems incapable of fertilization. Accomplishing this by two successive nuclear divisions, the surplus material is cast out within two minute cells, the so-called polar bodies, which appear at the micropylar pole of the egg within a few moments after it reaches the water, pass into the perivitelline space, and lose further significance in development. The maturation processes appear to be hastened by copulation (the contact of a spermatozoan, after entrance through the micropyle, with the vitellus), and indeed are largely coincident with this, but may take place quite independently of it, in which case the time required for the completion of the process is longer. Not until after the extrusion of the polar bodies is the egg mature and ready for the union of the egg, or female pronucleus, and the sperm, or male pronucleus, which constitutes the essential act of impregnation. When this union takes place there is constituted a cell fundamentally different

in its properties from the egg mother-cell which left the ovary, in that it is now a germ capable of further development into a complete organism. This process also could not be studied in the living mackerel egg, but probably does not there differ from what has been observed in the Spanish mackerel egg.

The spermatozoan of the mackerel consists of a pear-shaped head about 0.002 mm. in length, with a short rod-like middle piece attached like a stem to the narrow end of the pear, and bearing an exceedingly delicate flagellum or tail which is about 20 to 25 times the length of the head. When fully ripe, the sperm is quite fluid and mixes readily with sea water, through which the spermatozoa, by their very active lashing, quickly become disseminated. Under such circumstances, a very small quantity of sperm will serve to impregnate a great many eggs, and it is of practical importance to use as small a quantity as will effect the purpose, to the end that the eggs do not become clogged with great numbers of spermatozoa, which will adhere to their membranes and interfere with free respiration. With fresh and perfectly ripe sperm, the egg of the mackerel is very easily fertilized, even those eggs which exhibit a considerable degree of opacity, and are hence supposed to be less mature, responding at once to the presence of spermatozoa. In fact, even when considerable numbers of eggs, several hundreds of thousands, were handled, scarcely any would be found to be unfertilized, and in no case, except when the sperm or ova were obviously immature, did as many as 1 per cent fail of impregnation. This ease of fertilization and the almost perfectly uniform way in which the eggs would subsequently develop, all of them passing into the same stage at nearly the same moment, seem to me to indicate their healthful state and the necessity of seeking the cause of the failure of the hatching operations in some condition subsequent to this.

It is, of course, impossible, from the study of a relatively small lot of material obtained under only one set of conditions, and with no means of checking results by making comparisons, to state positively that the eggs were in the best vital condition, but the uniformity and regularity of results and the comparative scarcity of abnormalities, except those mentioned later on, seem to lead to this conclusion. My experiments to test the length of time during which the spermatozoa retained their fertilizing powers failed, owing to the accidental impregnation of the entire lot of eggs reserved for this purpose, and subsequently no opportunity for repeating the experiment was found. Direct observation, however, on sperm placed in pails or jars of water showed that the spermatozoa lost their activity completely in 45 to 60 minutes, and this period must consequently be admitted to be the extreme limit of their vitality under the conditions of the experiment.

I would here point out the futility of hoping for any better results through the substitution of the so-called dry method for the wet method of fertilization. The former was invented to meet certain peculiar conditions, and is indicated in cases where the contact of water with unfertilized eggs causes either the formation of a coat impervious to

the spermatozoa or the development around the vitellus of a water space which the spermatozoa can not traverse. Impregnation in the case of the mackerel is naturally and easily accomplished by the intimate mixture, in a small quantity of sea water, of the freshly stripped ova with a small amount of perfectly ripe sperm from a previously selected male. The objection to the adoption of the dry method lies in this: Owing to its greater weight the micropyle, which is the only point through which a spermatozoan can enter the egg, lies always at its lowermost pole. Now, when the eggs are only moist and the sperm is poured over them, a much greater quantity is needed, and more of it will adhere to the membranes than when the eggs are freely suspended and the micropyle exposed to the active swimming spermatozoa. The dry method may be just as effective as the wet, but it can not be more so, and has the slight disadvantage just mentioned.

Simultaneously with the progress of the internal act of fusion of the male and female pronuclei, other and more obvious external changes in the egg are taking place. The protoplasmic pellicle, which at first forms a layer of uniform thickness, begins to accumulate with a peculiar wave-like streaming at the lower or micropylar pole of the egg. At first the thickening thus produced is in the form of a scarcely evident meniscus, which passes off on all sides into the thin pellicle. Gradually it increases in thickness until nearly all of the protoplasm has accumulated in a sharply defined disc, the blastodisc, which, when completed, has a circular outline. Its outer surface is in contact with the egg-membrane and conforms very nearly to its curvature. The inner surface of the blastodisc has a strongly convex, almost conical, form and projects into the yolk. At its margins, which rise abruptly from the yolk, the blastodisc passes into continuity on all sides with the protoplasmic pellicle, which has now become reduced to an excessively thin and delicate, but perfectly intact, layer. The completed blastodisc becomes the seat of future developmental processes. The remainder of the protoplasmic pellicle takes but little part in these processes, and is known as the periblast layer. Oriented with reference to the micropyle, the blastodisc seems always to be a little eccentric, and the micropylar thickening is readily found just outside of its center. The perivitelline space, which is described above as an exceedingly shallow space between the egg-membrane and the mature vitellus, has now, owing to the change in form of the latter, altered its character. Owing to the contact of the greater part of the external surface of the yolk and of the blastodisc with the egg membrane, it is in these regions obliterated or so exceedingly shallow as to escape detection. But there is a deep ring-like space running all around the margin of the blastodisc and corresponding with a circular groove which forms the boundary between the yolk and disc.

The pellicle of protoplasm enveloping the oil-drop has, like that surrounding the yolk, collected in a bleb-like mass on the under surface of the oil. Its shape is similar to the blastodisc except that it is not constrained within a limiting membrane and has conformed to the charac-

ter of the fluids between which it lies, like the drop of water which gravitates to the under side of a soap bubble. This smaller disc takes no important part in development and undergoes no change until it becomes fused with the surrounding blastodisc. It will not be further considered.

Although just described as accompanying and succeeding fertilization, these processes must not be considered wholly as a consequence and therefore as a test of fertilization, for even in the absence of spermatozoa, changes almost precisely similar and likewise resulting in the formation of a blastodisc ensue, but are much later in reaching their fulfillment. In this case development never, so far as I have observed, proceeds any further, and in the course of a day or two the vitellus contracts, turns opaque, and rapidly disintegrates, the egg usually sinking to the bottom soon after the contraction becomes evident.

The brief chronological index to the stages of embryological development which follows is founded upon the time record of a series of embryos which developed at a mean temperature of 12.9° C. After the blastodisc has attained its greatest thickness and internal convexity, which occurs 1 hour and 20 minutes after impregnation, the heaped-up protoplasm slowly subsides, flattens a little, becomes slightly elongated along one axis, and remains quiescent for a time in this condition.

At 1 hour and 40 minutes after impregnation, the first segmentation furrow begins to appear as a narrow transverse depression across the middle of the outer surface of the disc, while on the inner surface appears a button-like elevation which is quickly subdivided by an internal depression placed exactly opposite to the external one. The halves of the button then subside and diverge, and, moving with a wave-like motion outward on each side of the internal furrow, cause a pair of prominent elevations to appear on this surface of the blastodisc. The external furrow rapidly extends to the margins of the blastodisc and cuts deeper into the protoplasm, which thus becomes almost separated into two equal halves or blastomeres, in each of which the protoplasm becomes actively heaped up. At the same time each blastomere tends to become circular, so that the blastodisc elongates in the axis at right angles to the first furrow. The segmentation furrow never cuts quite through the disc, but spares a thin layer of protoplasm on its deeper surface, so that the otherwise separate blastomeres remain connected by a protoplasmic web in contact with the yolk. The active process of division is completed very quickly. The heaped-up blastomeres then subside and pass into a resting state, during which the segmentation furrow becomes much less conspicuous. This condition is of relatively long duration, and it is interesting to note here that the slower development of this species as compared with the Spanish mackerel is due almost entirely to the greater duration of the resting periods, the periods of activity in each being of almost equal duration.

The second furrow, formed at right angles to the first, is completed in 2 hours and 35 minutes after the mixing of the ova and the sperm,

and the four blastomeres resulting will soon be found to have shifted around the polar axis of the egg from left to right, supposing one to be facing the external surface of the segmenting disk. Protoplasmic movements, followed by a long resting stage, characterize this as well as succeeding periods of development.

The third and fourth furrows, parallel respectively to the first and second, and resulting in the formation of 8 and 16 blastomeres, are completed in 4 hours. Already, at this stage, irregularities in segmentation begin to appear, and their frequency makes the mackerel somewhat remarkable among fishes having similar eggs and modes of development. Even in the 8-cell stage one of the blastomeres may be much smaller than the others, or pushed from its place to a deeper plane than its fellows. In the formation of the fourth cleavage one or two of the cells may fail to divide with the others, producing a stage with 15 or 14 cells, or the division may be unequal, and in nearly all cases it is unsymmetrical. In most teleostomous fishes such irregularities occur much less frequently and not so early in the developmental process. The Spanish mackerel, however, presents a similar case. Such irregularities may possibly indicate impaired vitality in the eggs studied, but, as they occur with such frequency in every lot of material examined, I am inclined to doubt this. In no case in which the future development of such eggs was followed did the normal growth of the blastodisc or embryo appear to be modified. The typical 16-cell stage forms a nearly square figure consisting of 12 marginal and 4 central cells, which latter have shifted spirally around the polar axis of the egg as mentioned above. Up to this time the segmentation has been perfectly rhythmical, occurring in all of the blastomeres at the same time, but, from now on, the central and marginal cells have a different history, which, however, soon becomes confused.

Following the 16-cell stage is one of 28 cells, resulting from the nearly simultaneous division of the 12 marginal cells; those at the angles of the square blastoderm dividing along planes approximately diagonal; those at the middle of the sides along planes parallel with the diameters. The central cells do not divide at this time, but soon follow with a horizontal division, thus making two layers of cells in the central part of the disk, while but one continues at its margin. Between 5 and 6 hours after the beginning of development the marginal cells divide again, resulting in a disk containing about 56 cells. From this time on the divisions occur in a more irregular way, though their rhythmic character is still apparent. The marginal cells are for a time smaller than the central ones, and begin to give rise to buds, in which lie the outer ends of the division spindles, which give rise to the periblastic nuclei. Succeeding the next division the cells of the entire blastoderm become of very irregular shape, horizontal as well as vertical cleavages are formed in all parts of the disk, and the marginal cells have their longer axes placed in radial directions preparatory to the rapid formation of the periblast nuclei and the superficial spread of the blastoderm which now begins.

After 12 hours of development the arc of the blastoderm occupies about one-fifth of the meridional circumference of the egg. Its inner surface is nearly flat, the outer slightly convex and the margins thin. In its central part the cells are 3 to 4 layers deep and, owing to the repeated horizontal divisions, now smaller than the marginal. The latter are surrounded by a wide periblastic wreath containing numerous nuclei.

At 16 hours the blastodermic rim is inflected and the embryonic thickening begins to appear.

At 20 hours the blastoderm occupies about 35 per cent of the surface of the ovum, and the embryonic shield has extended to its vertex.

At 30 hours the blastoderm has covered about 50 per cent of the surface of the ovum and the body of the embryo is distinctly outlined.

At 40 hours the blastopore is still about 0.5 mm. in diameter, and the embryo extends around about 35 per cent of the egg circumference. The notochord is distinctly differentiated. The eyes are just becoming defined as out-pushings. The embryonic body is deep and compressed below, but no myotomes are visible. No pigment has yet developed.

At 45 hours the blastopore has decreased in diameter to an average of 0.4 mm. The embryo extends nearly halfway around the egg. The eyes stand out from the head quite prominently as rounded masses. The first myotome is formed.

At 52 hours the embryo measures in total length 1.7 mm.; 5 myotomes, of which the first 2 are very distinct, may be counted in the middle region of the trunk. The head is clearly marked off. Pigment begins to appear and the chromatophores are arranged along the margins of the trunk of the embryo for its entire length. The nervous axis is very conspicuous.

At 60 hours the length of the embryo has increased to 1.9 mm. Pigment has become much more abundant and is aggregating on the head. There are 11 distinct myotomes. The crystalline lens is appearing as a thickened in-pushing of the epiblast. The blastopore is nearly closed.

At 70 hours the length of the extended embryo is 2 mm. The epiblastic involutions for the crystalline lens and the ear-sac are distinctly marked. The nasal involution is beginning to appear. The fourth ventricle of the brain is differentiated and the cerebellum is folding off. The lateral-line sense organs are apparent as epiblastic thickenings. There are 19 myotomes. The pigment cells have become more conspicuous and branching. No pigment is present anterior to the eyes. A small pointed caudal tubercle is forming as a preliminary to the outgrowth of the tail.

At 78 hours the embryo measures 2.1 mm.; 20 or 21 myotomes are present. The ear-sacs are now closed vesicles, just anterior to which appear the beginnings of a large sense-organ. The lens has sunken deep into the optic cup, its inner wall is thickened, and its orifice is closing. The olfactory vesicles also have their orifices much constricted.

At 88 hours after the beginning of development the embryo measures 2.3 mm. in length, and the tail has grown out free of the yolk to a length of 0.2 mm. The head has become broad and conspicuous, and measures 0.4 mm. across the eyes. The ear-sacs are still thick-walled, simple vesicles, measuring 0.1 mm. in length. The branchial sense organs are conspicuous. The pigment is now arranged principally in two lines along the margins of the body, a very few scattered cells appearing on its dorsal surface. Yellow pigment makes its first appearance behind the forming eyes.

At 102 hours the embryo measures 2.4 mm., the free tail 0.3 mm. The median fin ridge has begun to develop on the tail, which has now been deflected to the left side of the embryonic axis. The alimentary canal (mesenteron) is still an open groove for most, if not all, of its length. The mouth depression is appearing, with slightly marked maxillary and mandibular processes inclosing it. The branchial clefts appear as faintly defined furrows. The head is still very broad and flat. The heart pulsates actively, but somewhat spasmodically. The oil-sphere is closely applied against the base of the tail and is undergoing rapid absorption. Its protoplasmic sheath has fused with the blastoderm, and the pigment cells, which have now developed on its internal surface, have united by anastomosing processes to constitute a reticulum.

At 114 hours the embryo is 2.6 mm. in entire length; the free tail is 0.3 mm. The caudal fin-fold is quite prominent. The tail has now turned with its flat side toward the yolk. There are about 73 myotomes. The head has not yet begun to rise freely from the yolk-sac. A thickening near the anterior end of the alimentary canal indicates the outgrowth of the liver. The alimentary groove seems to be entirely closed.

Hatching usually takes place at 120 hours after impregnation. The newly hatched larva measures 3.3 mm. in length; the yolk-sac 1.3 mm. in length and 0.8 mm. in depth. The oil-drop has become much reduced and its inner surface flattened. It measures 0.28 by 0.15 mm. The head projects slightly beyond the yolk-sac. The mouth and gill slits are not yet opened, but there is a peculiar cleft beneath the edge of the yolk-sac, just over the branchial region. The cephalic sinus is small. Pigment is just beginning to appear in the retina. The yolk-sac is ovoid, and deepest toward its posterior end. The oil-drop is embedded in the posterior ventral part of the yolk-sac, having been pushed forward a short distance from the base of the tail, and at the same time has rotated so that the flattened pigmented surface is now outermost. Considerable individual variation was observed in the exact position of the oil-drop. There is no black pigment on the surface of the yolk-sac, of the median fin-fold, or on the ventral surface of the embryo, except where a few chromatophores sometimes migrate downward over the base of the tail. On the head the black pigment has now formed a conspicuous reticulum extending to the extremity of the snout. On the body and tail the pigment is more scattered, but is chiefly confined to two series of chromatophores located along the base of the dorsal fin and the lateral aspects of the tail. The individual

pigment cells tend to arrange themselves along the lines of the intermuscular septa, along which they are produced in slender, branching processes. Pale, greenish-yellow pigment appears in heavy masses, of which there is one on each side of the head behind the eye, another behind the oil-drop, and another on each side of the tail. This latter tends to be produced from the muscular trunk of the tail onto the dorsal and ventral fin-folds. On the third day after hatching the fry measure 3.75 mm., the yolk-sac is almost entirely absorbed, the mouth and the opercular slits are open and functional, the eyes are fully pigmented, and the pectoral fins have assumed their vertical position and adult proportions. By the fifth day after hatching the yolk-sac is entirely gone, the mouth is large and conspicuous, and the skeletal cartilaginous arches of the head are fully formed.

CAUSES AND CONSEQUENCES OF VARIATIONS AND ALTERATIONS IN THE SPECIFIC GRAVITY OF THE EGGS.

The eggs, when received at the ship, between 2 and 3 hours after mixing of the ova and sperm, were in the 2-cell to the 4-cell stage of development. At this time all of those which were mature and intact floated in a compact layer at the surface of water of a density which varied from 1.021 to 1.0226. One entire lot of 425,000, however, of what seemed to be particularly fine eggs of large size, and all fertilized, sunk at once in a density of 1.0216. When the density was raised to 1.0225 they slowly rose and just floated at the surface. To determine the variations in this respect among individual eggs, 100 living eggs were taken, all in the same condition and stage of development, and placed successively in water of different densities, with the following result:

Temperature.	Density.	Number of eggs sunken.	Number suspended.	Number floating.
19° C.	1.022	99	0	1
19° C.	1.024	66	10	24
19° C.	1.025	14	8	78
19° C.	1.0252	0	0	100

A careful comparison of the lightest and the heaviest eggs in the foregoing experiment showed that, excluding from consideration those which were immature or otherwise imperfect, the sunken eggs were more variable in size than the floating. The smallest were, in all probability, the not fully mature and more opaque eggs mentioned above. The larger sank because the oil-drop was relatively of a smaller size than in the eggs of intermediate size.

For the first 48 hours, at a temperature of 12.9° C., at which most of our observations were made, the eggs undergo no marked change in specific gravity. Those which sink during this period, unless a marked fall in the density of the water occurs, are either structurally imperfect or have, for some reason, died during the course of development. A very serious mortality occurred in many of our lots of eggs at about 18

to 24 hours after impregnation, when embryological development had reached the late blastula and early gastrula stage. When, during the early part of the third day of development, the body of the embryo is well formed, with from 3 to 8 myotomes differentiated, there is a marked increase in the specific gravity of the eggs. They then begin to sink slowly toward the bottom, most of them remaining for a long time in suspension, and a few (the number of which varies with the batch of eggs and the density of the water) retain their position at the surface. The cause of this increase in weight becomes more apparent as development proceeds. In the first place, it is to be noted that at about this time the oil-drop has been inclosed by the spreading blastoderm, and already on the third day shows signs of absorption in a flattening of the inner surface of the sphere and a diminution in size, shown by careful measurements. The oil-sphere, which at first measures about 0.29 mm. in diameter, has by the time of hatching decreased in one diameter to 0.16 mm., the other remaining at about its original size. The absorption of the yolk and oil-drop and the building-up of the more compact body of the embryo has, in the meantime, resulted in a contraction of the vitellus and an increase in the size of the perivitelline water space. The egg-sphere, therefore, while undergoing no increase in size, has come to include relatively more solid matter, and is therefore heavier.

I have gone somewhat fully into this matter, as I desire to show that the increase in specific gravity at this time and subsequently is a perfectly normal process. Probably any egg, the specific gravity of which is so nearly that of the density of the water in which it is developed—as was the case with these mackerel eggs—would undergo a similar submergence during the later phases of development. The eggs are not dead when they sink to the bottom (though of course those which have died will also sink), but lie among the mass of débris and sooner or later succumb to the influence of the decaying organic matter. This subject, with its probable significance and practical bearings, is considered in a later part of this report.

2. RESULTS OF SURFACE TOWINGS.

It was early in the course of the investigation considered that important aid might be rendered toward the practical ends of the work if the distribution of mackerel eggs deposited naturally in these waters could be determined, together with the environmental conditions under which they were obtained. To secure this information, surface towings were begun on June 26 and continued daily, except during the progress of two heavy storms, until July 27. After the arrival of Mr. Brett on July 1, the collection of this material and full physical and meteorological data bearing upon it were placed in his charge. Extensive and systematic examinations were made of the waters, especially about the eastern entrance of the bay, and less fully elsewhere. The material was fully examined by me, with special regard to the number and condition of the mackerel eggs present. The results were in part

quite unexpected, and in part probably confirmatory of conclusions stated in a previous part of this report.

The inshore waters of Casco Bay have been generally supposed to be one of the most important spawning-grounds of the mackerel on our coast. If this opinion be well grounded, one would expect to find large numbers of mackerel eggs on the surface, and I was consequently much surprised at the almost utter barrenness of the collections in this respect. Although other pelagic eggs of at least twelve species were found, some of them in very great abundance, most of the surface specimens yielded no mackerel eggs at all, or but two or three were detected among thousands of the eggs of other species. An unidentified species of egg, which in its early stages, could scarcely be distinguished from the mackerel, was found in some abundance, but, when developed, produced a larva having very different characteristics. The only occasions on which any considerable number of mackerel eggs were obtained was during the prevalence of south and southeast winds, which blew within the scope of our observations the offshore surface waters, a fact indicated by an increased density. One is, therefore, probably justified in concluding that during the season of 1897 only a very few mackerel spawned inshore in the vicinity of Casco Bay, and that spawning for the most part was accomplished at a greater or less distance out at sea. This conclusion, of course, does not necessarily invalidate former conclusions that the waters of Casco Bay constitute an important breeding-ground for this species, but simply establishes the fact that certain conditions, not at present definitely known, sometimes cause most of the mackerel to spawn farther off shore. It may be added that the literature of the mackerel contains much evidence confirmatory of this opinion.

Of the mackerel eggs obtained by surface towings, all were in early stages of development, the oldest containing embryos having 12 or 13 myotomes and extending about halfway around the egg; that is, they were in stages that are reached under the artificial conditions of propagation during the third day of development. Now, of the eggs of various other species of fishes, as of the cunner, sea bass, and scup, which habitually spawn inshore, those obtained under similar conditions exhibited many examples in later stages of development, and one would expect, if the mackerel egg remained similarly afloat until hatched, that among the 200 or 300 eggs collected at the surface some of the later stages would be sure to occur. The absence of such stages seems to confirm the observation that in water of the comparatively low density obtained here the eggs of this species will not float during the later stages of development. It is possible that the eggs of the mackerel are usually deposited so far out at sea that the density of the water to which they are subjected is sufficient to float them during the entire period of development. It may also be suggested that large numbers of them may be carried by winds or currents to the open ocean, and there find the conditions best suited to their welfare.

But suppose they do normally sink in the 20 or 30 fathoms of water found where they were collected, or in the still deeper water whence most of them in all probability came, what conditions do they meet?

First, a column of water many (several hundred) times as high as that in the boxes and jars in which artificial propagation has been attempted. For a body of but little lower specific gravity to pass through such a stratum of water would require, even were the water in a perfectly quiescent state, a very considerable length of time—perhaps quite sufficient to permit hatching before the bottom is reached. But the constant slight movement to which these waters are subject owing to their agitation by tide, winds, and constant currents would greatly prolong the time of descent.

Secondly, the density undergoes a constant and in deep water a frequently considerable increase toward the bottom, so that the egg in its progress downward would always pass through water of a density corresponding to its own increasing specific gravity, and would thus be constantly buoyed up by a nicely adjusted force, the result of which would be to further delay it.

It is probably safe to conclude, then, that under natural conditions the egg of the mackerel is always suspended in water of a density very nearly equal to or greater than its own, and that it does not normally settle to the bottom and rest there in a mass of filth, and subjected to conditions of imperfect oxygenation, etc., which is the case in the forms of artificial hatching apparatus, namely, the Chester and McDonald systems of tidal boxes which have hitherto been chiefly employed. Another consideration to be noted is that the parallel increase in density of the water and the specific gravity of the egg will result in the maintenance of a nice balance of osmotic pressure which may possibly be a requisite to a healthful development. Three other conditions of change relate to light, oxygenation, and temperature, all of which decrease toward the bottom.

3. RESULTS OF EXPERIMENTS.

When the results of biological investigations of the conditions of development were sufficiently advanced to have led to the conclusion just briefly outlined, several important lines of experimentation seemed to be indicated. Direct observation of the changes in the living egg and of the conditions affecting the distribution of the egg in nature having suggested the importance of an increasing water density, a series of experiments designed to test the influence of this condition was first planned. Indeed, owing to the paucity of material and the limited time in which to work, this series was the only one which was conducted in anything like a systematic manner, and even here the results of individual experiments, which could not be repeated and verified, are too meager to be conclusive.

A description of one or two of these experiments, with their results, will suffice to indicate the general character and bearing of all.

Lot *D* consisted of 109,000 eggs, yielded by two females taken in the trap net of Mr. Sennett, June 26. Sperm and ova mixed at 5.15 p. m. All of the eggs were fertilized and in the 4-cell stage when examined on board the ship shortly after 7 p. m. All were placed in a McDonald cod-box, in which they floated buoyantly in water of a density of 1.0221. The eggs were allowed to remain without change all through the next day and until the morning of June 28, when, at the age of 40 hours, they were approaching the period of development when, according to previous observations, they might be expected to pass into suspension. Up to this time the mortality had been very small, and was chiefly the result of eggs having adhered to the somewhat rough wooden sides or the corners of the McDonald boxes, when they were left high and dry by the receding water and killed.

At 11 a. m. on June 28, at which time the blastopore had just closed, three lots of eggs, estimated to contain 25,000 each, were removed from the McDonald box and subjected to the following conditions: One lot, designated as sublot *DA*, was placed in a second McDonald box under conditions precisely similar to the first, and was retained as a check on the other sublots.

A second sublot, designated as *DB*, was placed in an apparatus designed to imitate the Chester tidal boxes and jar, arranged by cutting the bottom out of a 2-quart Mason butter jar, tying cheesecloth over both ends, and placing this upright in a pail provided with a siphon hose. The eggs were placed within the glass cylinder in water which had been gradually increased in density, and the apparatus then supplied with water, the density of which had been raised by adding a solution of rock salt to 1.0252, this having been previously determined to be the density in which the eggs would just float at this period of their development. About 500 gallons of this density of water, sufficient to fill one of the large deck boxes, was made up to supply the apparatus. After the height and rate of the tidal flow had been adjusted to that customarily adopted for the McDonald boxes, the apparatus was left to itself, except that it was necessary to replace the water in the supply tank and aerate it about every 12 hours.

The third sublot, designated *DC*, was also passed gradually into the water of 1.0252 density, and then placed in a box provided with cheesecloth bottom, which was floated in the supply box of high-density water on deck.

The history of these three sublots briefly told is as follows: During the next 24 hours, those comprising *DA* had gradually settled, becoming distributed all through the water and on the bottom, although the density had increased to 1.0226. The eggs were alive and the oil-sphere had begun to be absorbed. In sublot *DB* the eggs all floated in a compact layer at the surface of the water. They were slightly more advanced in development than *DA* and the oil-drop was smaller. Of sublot *DC* many of the eggs had been killed by rupture of the membrane or other injury caused by striking or sticking to the sides of the box while washing to and fro in the tank.

During the fourth and fifth days of development, most of the eggs of sublot *DA* lay on the cheesecloth at the bottom of the box and the embryos gradually grew weaker until they finally succumbed. A very few, about several hundred, hatched, but all died within 24 hours. The eggs of *DC* were almost all destroyed by being injured or stranded on the side of the floating box. Those of *DB* continued to develop beautifully until the close of the fourth and beginning of the fifth day, up to which time they had continued to float with only a very small percentage of loss. At this time they were nearly ready to hatch, having developed at a higher temperature and more rapidly than *DA*, but now they began to die rapidly and within a few hours the entire lot succumbed. A heavy rain-storm occurred about this time, and the density of the supply of salter water was found to have dropped to 1.024. But I do not attribute the mortality to this, because many of the embryos were observed to die while floating at the surface, to contract, turn opaque, and sink just as they do when affected by some deleterious substance.

Results practically similar to these were obtained in all experiments with higher densities, the encouraging feature being that, by this means, a much larger proportion usually remained alive until late stages of development than when low-density waters were employed. In no case was a greater number hatched, and in no case did the fry thus reared appear to be more vigorous.

Another rather interesting result was obtained by taking eggs which had sunken to the bottom of the usual apparatus and placing them in a circulating current in the McDonald shad jar, the outflow being protected by cheesecloth cage. Under such circumstances the numbers hatched were always larger than in samples of the same eggs which were left undisturbed, and fry already hatched could be kept alive and vigorous for a much longer time. Some were thus kept for 5 days, when the yolk-sac was absorbed, and they were ready to begin feeding. Half of one lot (lot *G*) of over 400,000 eggs, all of which sunk at once after fertilization, were thus treated. The remaining half being placed in a McDonald cod-box, every one of the eggs which had lain at the bottom of the box was dead before 36 hours had passed. The eggs placed in the closed current jar continued to develop up to the last day and some of them hatched. Probably the proportion hatched would have been much greater could the eggs have been prevented from piling up on the outlet screen and injuring one another by the pressure. Numerous other experiments were carried out, but none were more conclusive or satisfactory than those just indicated. It was found impossible, with the limited facilities, to be sure that only one condition had been varied, and that some other factor had not arisen to vitiate the results. In view of the fact that in no case was a greater per cent than 50 hatched, and that only once attained, it seems useless to describe the results with further detail. It seems proper to add that Mr. Corliss, superintendent of Gloucester station, advises me that he

has this year attained much more encouraging results, having hatched in some cases over 80 per cent of the eggs placed in the McDonald cod apparatus.

SUMMARY AND CONCLUSIONS.

Following is a brief summary of what seem to be the most important results of the summer's work, but I wish particularly to point out that the statements contained in this report, based upon the limited data of but one season's experience, have not the force of final conclusions, but are offered as suggestions only, which I hope may be useful to the next student who takes up the problem of mackerel propagation:

During the season of 1897 the common mackerel spawned only very sparingly within the limits of Casco Bay, but in greater numbers at some unknown distance off the coast. Those fish which entered Casco Bay after July 1 were in mixed schools, but most of the females were already spent, or partly so. The best run of spawning fish occurred in this region, according to the united testimony of the fishermen, during the first half of June.

For each individual mackerel the season of productiveness extends over several weeks, the eggs being produced in several batches, which mature in succession. Night spawning is probably the rule with the mackerel, but the eggs probably continue to be dehisced into the ovarian cavity during most of the day. I have collected an abundance of evidence bearing on this point.

There are indications that eggs produced by mackerel in different regions differ in size. This may result from the existence of quite different schools or races. During the course of its development the egg increases in specific gravity, owing to absorption of the oil-drop, and sinks beneath the surface, where it encounters higher densities and other changed conditions.

The morphology of development does not differ in essentials from that of the cod, Spanish mackerel, and sea bass, which has been well described in publications of the United States Fish Commission. Irregularities of segmentation occur with unusual frequency and at unusually early stages.

The eggs collected from trap nets in the latter part of the afternoon, though sometimes presenting evidence of being not quite mature, were very easily fertilized and seemed to be healthy.

Fertilization should be effected by the wet method and immediately, as the sperm retains its vitality for a short time only.

The fertilized eggs are best transported in vessels of water; cheesecloth and muslin trays have proved unsatisfactory. The eggs should be freed of surplus sperm and be prevented from overheating.

The indications are that the poor results attained on the *Fish Hawk* are due not so much to the poor quality of the eggs as to some defect in the apparatus, possibly to some deleterious substance introduced somewhere in the hydraulic system.

The results of experiments indicate no form of apparatus better for the first two days of development than the usual tidal boxes, provided the sides are smooth, preferably of glass or enamel, and provided that the screens are kept free of any deleterious substances. For the later days of development and for the fry after hatching a higher density and greater purity of water and a form of apparatus that insures a better circulation and keeps the ovum in suspension without undue agitation is indicated.

Being very delicate and sensitive to physical injury and the presence of deleterious substances, the eggs should be handled as little as possible. A relatively small number should be placed in one receptacle, not more than would form a single layer on the surface (Mr. Corliss's opinion on this point differs from mine, he claiming to have had equal success with large and small numbers), and especially the hatching apparatus should be kept as free as possible from decaying organic matter or other contaminating substances.

RECOMMENDATIONS.

The experience of the past few years seems to render it sufficiently obvious that unless some very different conditions obtain in future there is little to be hoped for from the methods of propagating the mackerel now in vogue. The few millions of eggs annually secured are so insignificant in comparison with the vast numbers which must be produced naturally that even if all were hatched the fry resulting would be a mere drop in the ocean.

It is well known that the purse-seine fishermen operating some miles offshore frequently secure whole schools of spawning mackerel, from which the eggs run so freely that decks of fishing vessels become literally covered with those which have accidentally escaped. This circumstance, coupled with the before-mentioned fact of the readiness with which fertilization can be accomplished, leads to the following suggestion, which I recommend as a guide toward a tentative policy of the Fish Commission during the progress of further investigations:

The captains of the fishing schooners should be asked to cooperate upon such terms as may be agreed upon, to the end that when such spawning schools of mackerel are met with the fish should be immediately stripped, the ova and sperm mixed, and, after permitting a few minutes to insure fertilization, turned overboard to undergo their development amid the natural surroundings from which they were taken. In this way, especially when such schools were taken in the late afternoon or at night, vast numbers of fertilized and healthy eggs could be liberated under conditions which have been previously indicated as those most favorable to their growth.

The work of stripping and impregnation can be accomplished so simply and quickly that it would not materially interfere with the regular duties of fishing, and I have no doubt that the more intelligent fishermen, particularly in view of some small consideration, could accomplish

it successfully. Each schooner could be provided with a circular of instructions and such vessels (large, shallow pans) as would be needed to insure the intimate contact of spawn and sperm when mixed. It may even be deemed advisable, though this seems hardly necessary, to place experienced spawners on vessels which would make favorable terms, to conduct the operations.

In presenting this suggestion one additional factor needs to be emphasized. While the exact spawning habits of the mackerel are unknown, the probability is that this function is accomplished while the males and females are actively swimming about together at a greater or less depth below the surface. The spermatozoa are probably more or less widely disseminated through the water. The ova are squirted out in a stream, and, being at this time highly buoyant, immediately begin to rise toward the surface, the micropyle, through which alone the spermatozoan may enter, being downward. Under such circumstances many ova must escape fertilization. That such is the case is shown by the very considerable number of unfertilized eggs which were observed among those of the mackerel collected in the surface towings this summer, and still better by my observations on the eggs of the cunner, of which fully 30 per cent of those examined had failed of fertilization. This shows that one very considerable advantage of artificial over natural propagation of pelagic fish ova is derived from an increased effectiveness of the means of bringing the sexual elements into contact. No doubt much may be gained by continuing the care of the developing ova to a later stage, when the means for so doing, as in the case of the shad, is effective; but when, as is at present the case with the mackerel, there are lacking facilities for prosecuting the work further under such circumstances as will insure a profitable scope of operations, it seems best to adopt the merchant's dictum of "small profits and large sales." No doubt the time will come when the means will be provided for carrying the eggs collected in this way up to the time of hatching.

It needs also to be pointed out that most of the eggs which would be produced by spawning schools thus captured are now entirely lost, and that this fact alone, in the case of the lobster, has been regarded as sufficient to commend the present mode of propagating that species; although here what was said above of the advantage to be gained by artificial fertilization is not applicable.

The advantages of this plan are economy and the possibilities of extensive operations; the disadvantage is its probable uncertainty from year to year.

REPORT

ON

FISHES OBTAINED BY THE STEAMER ALBATROSS

IN THE VICINITY OF

SANTA CATALINA ISLAND AND MONTEREY BAY.

REPORT ON FISHES OBTAINED BY THE STEAMER ALBATROSS IN THE VICINITY OF SANTA CATALINA ISLAND AND MONTEREY BAY.

By Charles H. Gilbert, Ph. D.,
Professor of Zoology, Leland Stanford Junior University.

The fishes here reported on were collected by the United States Fish Commission steamer *Albatross* in April, 1897, during the progress of investigations conducted in the vicinity of Santa Catalina Island and of Monterey Bay in southern California. They were obtained by the use of the seine and of the hand line, trawl line, gill net, and dredge, usually at inconsiderable depths, and are therefore for the most part the common shore and market fishes of this region. Two dredge hauls and two sets of the gill net were at greater depths than 200 fathoms. The discovery of an undescribed species of *Averruncus* and one of *Radulinus* emphasizes again the great development of Agonoid and Cottoid fishes in the North Pacific.

LIST OF FISHES.

Polistotrema stouti (Lockington). Santa Cruz; Station 3669.

Raja inornata Jordan & Gilbert. Station 3665.

Hydrolagus colliei (Lay & Bennett). Station 3666.

Clupea pallasii Cuvier & Valenciennes. Santa Cruz.

Clupanodon cæruleus (Girard). Santa Catalina Island.

Engraulis mordax Girard. Santa Cruz; Santa Catalina Island.

Mesopus pretiosus (Girard). Santa Cruz.

Chauliodus macouni Bean. Station 3669.

Gasterosteus cataphractus microcephalus Girard. Santa Cruz.

Siphostoma griseolineatum (Girard). Santa Cruz.

Atherinopsis californiensis Girard. Santa Cruz; Santa Catalina Island.

Atherinops affinis (Ayres). Monterey; Santa Catalina Island.

Roccus lineatus (Bloch). Monterey; Santa Cruz. Introduced species.

Paralabrax clathratus (Girard). Santa Catalina Island.

Umbrina roncador Jordan & Gilbert. Santa Catalina Island.

Abeona minima (Gibbons). Santa Cruz.

Amphistichus argenteus Agassiz. Santa Cruz.

Pimelometopon pulcher (Ayres). Santa Catalina Island.

Oxyjulis modestus (Girard). Santa Catalina Island.

Sebastolobus alascanus Bean. Stations 3666, 3667, 3669, and on trawl line set in 10 to 15 fathoms at entrance to Dakin Cove, Santa Catalina Island.

This fine species of red rockfish occurs outside the zone of profitable fishing for the market, and is unknown to the fishermen. An individual occasionally strays into shallower water, as seen by the above record. More recently, a specimen was taken by fishermen in Monterey Bay, and found its way to the San Francisco market.

Sebastolobus altivelis Gilbert. Station 3670. Ten specimens were preserved, of which 9 have 15 dorsal spines, while 1 has exceptionally 16 spines as in *S. alascanus*.

Sebastodes goodei Eigenmann & Eigenmann. Station 3671. Hand line near Monterey, 69 fathoms.

Sebastodes paucispinis (Ayres). Santa Catalina Island; Monterey Bay.

Sebastodes serranoides Eigenmann & Eigenmann. Santa Catalina Island.

Sebastodes flavidus (Ayres). Monterey Bay.

Sebastodes mystinus Jordan & Gilbert. Monterey Bay.

Sebastodes pinniger (Gill). Monterey Bay.

Sebastodes miniatus (Jordan & Gilbert). Monterey Bay; Santa Catalina Island.

Sebastodes saxicola (Gilbert). Stations 3665, 3667, 3671.

Sebastodes introniger Gilbert. One specimen 44 cm. long; locality unknown.

This species has been identified with *S. melanostomus* Eigenmann, by Cramer and by Jordan & Evermann. The types of the two have not been compared, and the description of *S. melanostomus* fails to agree in so many details with specimens of *S. introniger* that it seems best to keep the two apart. *S. introniger* has the head larger, $2\frac{4}{5}$ in total length. The interorbital space is narrower, $5\frac{1}{5}$ in length of head. The scales are larger, 34 in the course of the lateral line. The accessory scales are very numerous. The gillrakers are much longer, the longest contained $2\frac{1}{3}$ to $2\frac{1}{2}$ times in the diameter of the orbit. The second and third anal spines are equal, or the second slightly the longer, contained $1\frac{1}{4}$ times in longest anal ray. In *S. melanostomus* the head is $3\frac{1}{4}$ in total length, there are 43 scales in the lateral line, and but few accessory scales. The gillrakers are contained $3\frac{1}{2}$ times in the diameter of orbit. The anal spines are graduated, the second "not much more than half the length of the soft rays." Two specimens of *S. introniger*, 30 cm. and 44 cm. long, entirely agree with each other in the respects above mentioned. The differences alleged to separate the two species can not, therefore, be due to age.

Sebastodes ruberrimus Cramer. Monterey.

Sebastodes constellatus (Jordan & Gilbert). Santa Catalina Island.

Sebastodes chlorostictus (Jordan & Gilbert). Station 3666.

Sebastodes elongatus (Ayres). Stations 3664, 3665, 3666, 3671, 3672.

Sebastodes vexillaris (Jordan & Gilbert). Monterey; Santa Catalina Island.

Sebastodes maliger (Jordan & Gilbert). Monterey.

Sebastodes carnatus (Jordan & Gilbert). Monterey.

Sebastodes serriceps (Jordan & Gilbert). Santa Catalina Island.

Scorpæna guttata Girard. Stations 3664, 3665; Santa Catalina Island.

Ophiodon elongatus Girard. Santa Cruz.

Zaniolepis latipinnis Girard. Stations 3662, 3663.

Zaniolepis frenatus Eigenmann. Station 3663.

Chitonotus pugetensis (Steindachner). Station 3663.

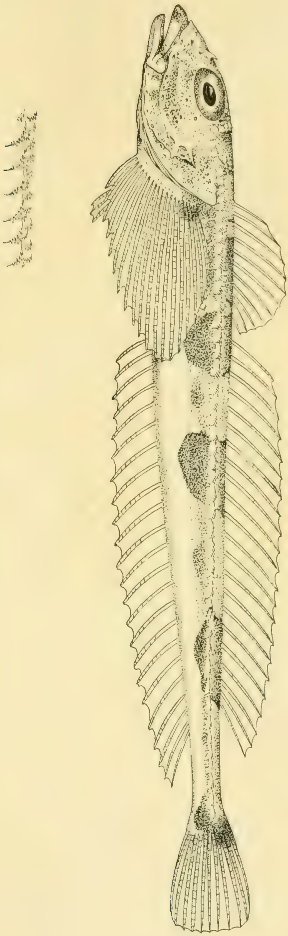
Tarandichthys tenuis (Gilbert). Stations 3662, 3663, 3664.

Icelinus quadriseriatus (Lockington). Station 3663.

Radulinus boleoides, new species. Plate 1. Type, a young female specimen, 72 mm. long, from Albatross Station 3664. Differing from *R. asprellus* in the much smaller eye, the scaled interorbital space, the presence of supraocular and occipital filaments, the smaller size and weaker spines of plates of the dorsal series, and the different coloration.

Head 4 in length; depth 9. Eye $3\frac{2}{3}$ in head ($2\frac{2}{3}$ in *R. asprellus* of the same size); snout $3\frac{1}{3}$; maxillary $2\frac{2}{5}$. Dorsal XI-22. Anal 23. Pectoral 18. Ventrals I, 3. 42 plates in the dorsal series.

Head and body very elongate, depressed anteriorly, the occiput wider and flatter than in *R. asprellus*. Snout long, depressed, and tapering, much as in the darters. Interorbital space very narrow, about half diameter of pupil. Mouth horizontal at lower side of snout, the maxillary reaching a vertical which trav-



RADULINUS BOLEOIDES. New species.

Lower figure is an enlarged view of dorsal spinous plates.

erses eye midway between its front and front of pupil. Fine teeth in bands in jaws and on vomer; none on palatines. In *R. asprellus*, also, the vomerine teeth are in a band, not in a single series, as stated in the original description. Branchiostegal membranes broadly united, wholly free from the isthmus in the type. In *R. asprellus* the gill-membranes vary in this respect, being sometimes wholly free from the isthmus, sometimes attached for half or more than half their width. Preopercle with two short, simple spines, the upper slender and sharp, directed backward and slightly upward, the lower broader and shorter, directed backward and downward. Below and in front of these are two rounded prominences which bear no spines. Opercle ending in a triangular process, which is scarcely spine-like. Nasal spines rather small, a depression between and behind them. No spines on orbital rim, which is not at all raised. The narrow interorbital space is not grooved. Occiput broad and flat, without ridges or spines. A slender filament on upper posterior border of orbit. A similar filament on each side of occiput on its posterior line.

Body with a dorsal series of imbricated spinous plates, similar to those in *R. asprellus*. But the plates are smaller, with less evident keels and shorter spines. Along its anterior third the series is accompanied above by a narrow band of smaller plates, which are continued anteriorly on sides of occiput, and merge anteriorly into the patch behind and between the eyes. Posterior portion of snout, the opercles, and the posterior line of occiput with spinous scales; head otherwise naked.

The vertical fins have long, slender rays as in *R. asprellus*. The dorsal fins are separate, but the interspace is less than the diameter of the pupil. The distance from front of anal to vent equals two-thirds diameter of orbit. Ventrals short, reaching half way to front of anal. Pectorals reaching slightly beyond front of anal, seven-eighths length of head.

Color light olive or grayish, the lower parts unmarked, the breast and belly silvery. Back crossed by four wide brownish-olive crossbars, the anterior of which, under spinous dorsal, becomes merged into the general brownish-olive coloration of upper portion of head and nape. The edges of the bands are sharply defined, and are marked with concave indentations where encroached upon by roundish light-colored areas. The spaces between the bands are slightly dusky and are marked with some irregular, small, dark blotches along middle of sides. Anteriorly on the back are pairs of round, light-colored spots with darker edges, some of them showing silvery pigment. A small silvery spot above the base of each pectoral fin. A narrow dark line across occiput behind the eyes. Dusky blotches on cheeks. A dark bar across the maxillary and lip; a pair on premaxillaries. Two faint dark bars on the caudal fin, the fins otherwise translucent or whitish, unmarked.

Clinocottus analis (Girard). Santa Catalina Island.

Averruncus sterletus, new species. Plate 2. Type, 103 mm. long, from Albatross Station 3662.

Very closely related to *A. emmelane*, with which it agrees in coloration and general appearance, as well as in most details of structure. It differs in the following respects: The snout is shorter, the rostral spines scarcely protruding beyond the premaxillaries; no barbels on snout below rostral spines or on margin of preorbital, or at mandibular joint; region between rostral spine and front of premaxillaries wholly occupied by a triangular movable plate, with rough, granular surface; breast with three parallel series of sharply keeled plates; no spine at posterior end of premaxillary fossa; ventrals very long and slender, wholly white; spinous dorsal, anal and pectorals with fewer rays.

Head $4\frac{3}{5}$ in length; width at base of pectorals, 7; depth $8\frac{1}{2}$. Dorsal VII–8. Anal 9. Pectoral, 12 on each side. Thirty-nine plates in dorso-lateral series.

Rostral projection shorter than in *A. emmelane*, with two short, forwardly directed spines, behind which is a pair more widely separated, directed upward

and backward. Supraocular ridge elevated, not sharp, finely granular, with preocular and postocular spines. Ridges and spines on head as in *A. emmelane*, but none of the former rough-serrate. Eye large, $3\frac{1}{4}$ in head, longer than snout and more than twice the interorbital width. Mouth little overpassed by the rostral spines, the maxillary reaching slightly behind front of orbit, $3\frac{1}{6}$ in head. Teeth present on jaws, vomer and palatine. Barbels fewer than in *A. emmelane*. Three are present on maxillary, two of which are at its posterior end, the upper much the longer. The third is inserted more anteriorly, behind the middle of the maxillary. Eight shorter barbels are present on each mandibular ramus, the posterior only near the joint. Several short barbels on gular region, and a cross series on branchiostegal membranes, usually one barbel for each ray. Plates on the body as in *A. emmelane*, all with sharp spines, which are present, though small in the ventral series. Middle of breast with one median and two lateral series of plates, all of which bear distinct longitudinal keels. The two lateral ridges on breast are the anterior continuation of the ventral ridges of the trunk.

The spinous dorsal begins at the seventh dorsal plate, the last dorsal spine articulating with the thirteenth plate. The first and last rays of the second dorsal articulate, respectively, with the eighteenth and twenty-fourth plates. The dorsal series unite at the thirtieth plates, the median series of nine plates thus formed bearing double or bifid spines throughout. The first and the last anal rays articulate, respectively, with the sixteenth and twenty-third plates of ventral series (excluding the anterior three on breast). The ventral series coalesce immediately opposite the union of dorsal series. The anus is opposite the interspace between the third and fourth plates. Ventral spines long and slender, equaling length of snout and eye. Pectorals equaling length of head in advance of opercular joint. Five lower pectoral rays with incised membranes, the tips projecting.

Color similar to *A. emmelane*, the back and sides with 7 or 8 narrow black crossbars, the posterior of which extend faintly on the under surface. The interspaces on back are somewhat dusky, with lighter vermiculating lines and spots, a few of which extend on the bars. The dorsals have a speckled appearance, and are darker above the black dorsal bars. Head blackish above, the head and body light or slightly dusky below. Ventrals white. Anal white, with some black markings along the base of the rays. Pectorals with a wide black bar at base, succeeded by a wide white bar, followed by a narrower black bar and a narrow terminal white bar. Caudal with a narrow basal bar of black, then a narrow white bar followed by a broad black bar, and edged with white.

Xenochirus latifrons Gilbert. Stations 3665, 3671, 3672.

Xenochirus triacanthus Gilbert. Station 3664.

Furcella diaptera (Gilbert). Station 3667.

Macrourus acrolepis Bean. Station 3670. One taken in a gill net set in 581 fathoms, vicinity of Monterey Bay.

Lyopsetta exilis (Jordan & Gilbert). Stations 3661, 3665, 3666, 3667, 3671.

Eopsetta jordani (Lockington). Monterey; Santa Catalina Island.

Psettichthys melanostictus Girard. Santa Cruz; Monterey.

Hippoglossina stomata Eigenmann & Eigenmann. Stations 3662, 3663.

Citharichthys sordidus (Girard). Stations 3662, 3663, 3664, 3665, 3668, 3671.

Parophrys vetulus Girard. Monterey; Santa Catalina Island.

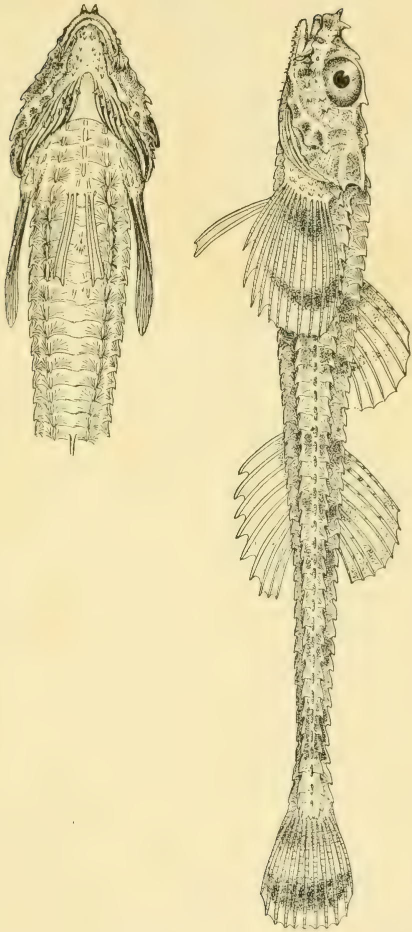
Lepidopsetta bilineata (Ayres). Station 3664.

Platichthys stellatus (Pallas). Santa Cruz.

Embassichthys bathybius (Gilbert). Stations 3669, 3670. One specimen taken in a gill net in 278 fathoms, Monterey Bay.

Microstomus pacificus (Lockington). Stations 3669, 3672.

Glyptocephalus zachirus Lockington. Stations 3669, 3671, 3672.



AVERRUNCUS STERLETUS. New species.

Lower figure is a ventral view.

LIST OF DREDGING STATIONS AND THE FISHES TAKEN AT EACH STATION.

Station 3662, off Santa Catalina Island; 47 fathoms.
- Zaniolepis latipinnis.
- Tarandichthys tenuis.
- Averruncus sterletus.
- Hippoglossina stomata.
- Citharichthys sordidus.

Station 3663, off Santa Catalina Island; 47 fathoms.
- Zaniolepis latipinnis.
- Zaniolepis frenatus.
- Chitonotus pugetensis.
- Tarandichthys tenuis.
- Icelinus quadriseriatus.
- Hippoglossina stomata.
- Citharichthys sordidus.

Station 3664, off Santa Catalina Island; 80 fathoms.
- Sebastodes elongatus.
- Scorpæna guttata.
- Tarandichthys tenuis.
- Radulinus boleoides.
- Xenochirus triacanthus.
- Lyopsetta exilis.
- Lepidopsetta bilineata.

Station 3665, off Santa Catalina Island; 59 fathoms.
- Raja inornata.
- Sebastodes elongatus.
- Sebastodes saxicola.
- Scorpæna guttata.
- Xenochirus latifrons.
- Lyopsetta exilis.
- Citharichthys sordidus.

Station 3666, off Monterey Bay; 68 fathoms.
- Hydrolagus colliei.
- Sebastolobus alascanus.
- Sebastodes elongatus.

Station 3666, etc.—Continued.
- Sebastodes chlorostictus.
- Lyopsetta exilis.

Station 3667, off Monterey Bay; 90 fathoms.
- Sebastolobus alascanus.
- Sebastodes saxicola.
- Furcella diaptera.
- Lyopsetta exilis.

Station 3668, off Monterey Bay; 39 fathoms.
- Citharichthys sordidus.

Station 3669, off Monterey Bay; 278 fathoms.
- Polistotrema stouti.
- Chauliodus macouni.
- Sebastolobus alascanus.
- Embassichthys bathybius.
- Microstomus pacificus.
- Glyptocephalus zachirus.

Station 3670, off Monterey Bay; 581 fathoms.
- Sebastolobus altivelis.
- Macrourus acrolepis.
- Embassichthys bathybius.

Station 3671, off Monterey Bay; 56 fathoms.
- Sebastodes goodei.
- Sebastodes elongatus.
- Sebastodes saxicola.
- Xenochirus latifrons.
- Lyopsetta exilis.
- Citharichthys sordidus.
- Glyptocephalus zachirus.

Station 3672, off Monterey Bay; 68 fathoms.
- Sebastodes elongatus.
- Xenochirus latifrons.
- Microstomus pacificus.
- Glyptocephalus zachirus.

NOTES

ON THE

EXTENT AND CONDITION OF THE ALEWIFE FISHERIES OF THE UNITED STATES IN 1896.

BY

HUGH M. SMITH.

NOTES ON THE EXTENT AND CONDITION OF THE ALEWIFE FISHERIES OF THE UNITED STATES IN 1896.

By Hugh M. Smith.

THE ALEWIVES OR RIVER HERRINGS.

Alewives are the most abundant food-fishes inhabiting the rivers of the eastern coast of the United States, and, next to the shad, are commercially the most valuable fishes of those waters. Although their range is similar to that of the shad—namely, from Maine to Florida—they are somewhat more generally distributed; they enter all the rivers frequented by shad and also annually visit in large numbers many other streams.

The two species of alewives are very similar in appearance and habits, and may easily be mistaken for each other on casual observation. They are usually distinguished by fishermen and dealers and receive different names, but the identification of individual specimens by fishermen is often faulty, as they depend more on the time of the run and the denseness of the schools than upon any reliable structural or color characteristics.

The branch herring (*Pomolobus pseudoharengus*) is found from North Carolina northward along the entire coast; if it exists at all in the rivers of South Carolina and Georgia it is very rare, and extensive collections of fishes in the St. Johns River, in Florida, have failed to disclose its presence. It is extremely abundant in Albemarle Sound, Chesapeake Bay, Delaware Bay, New York Bay, and their tributaries, and in the rivers, ponds, and bays of New England. It appears earlier than the other alewife, usually preceding the first run of shad, and ascends to the headwaters of streams to spawn.

The glut herring (*Pomolobus æstivalis*) is common in the St. Johns River, Florida, and is found thence northward along the entire coast of the United States, being most abundant in Albemarle Sound and Chesapeake Bay. It usually appears, suddenly, about the middle of the shad season, coming in enormous schools. It does not, as a rule, ascend the streams far above tide water, and spawning takes place at a shorter distance from the sea than in the case of the branch herring.

The branch herring may be readily distinguished from the glut herring by the pale lining (peritoneum) of the abdominal cavity, this structure being black in the glut herring. Other features by which the two fishes may be identified are the deeper body, more elevated fins, and larger eye of *P. pseudoharengus*.

The size of alewives taken for the market is quite uniform. The average weight is two-fifths or one-third of a pound, the two species being similar in this respect. Examples weighing as much as half a pound are rare.

As food-fishes, the alewives are generally regarded as superior to the sea herring, being larger and of better flavor, but they are decidedly inferior to the shad in food value. There is very little difference in the edible qualities of the two species, although the branch herring has the reputation of being somewhat better. Many reach the market in a fresh condition, but perhaps the largest quantities are salted or smoked, smoking being a favorite method of preparation in New England. For use as bait in the line fisheries for cod, haddock, and other ground fish, alewives are considered highly satisfactory, and large numbers are thus utilized in Maine and Massachusetts. The abundance and cheapness of these fish make them of almost incalculable importance in the coast sections, and in 1896 nearly 150,000,000 were sold by fishermen of 14 States for food and bait, besides which large quantities were given away at the fishing shores. The average price received by the fishermen was one-third of a cent per fish.

These fishes are known by a large number of names along different parts of the coast. In the New England States the name alewife is in general use, while in the Middle and South Atlantic States "herring" is the name most frequently heard. The branch herring is known as spring herring, branch alewife, gaspereau, wall-eyed herring, hardhead, alewife, ellwife, and ellwhop. Among the names for the glut herring are blueback, May herring, school herring, summer herring, blackbelly, English herring, kyack, cat-thrasher, and sawbelly.

THE ALEWIFE FISHERIES CONSIDERED BY STATES.

Alewives are caught in much larger numbers than any other fishes entering the fresh waters of the United States, and among all the fishes of American waters are surpassed in this respect only by two species, the sea herring (*Clupea harengus*) and the menhaden (*Brevoortia tyrannus*). They are taken for commercial purposes in every seaboard State from Maine to Florida, except Georgia, in which an alewife fishery was formerly carried on. Maryland, North Carolina, and Virginia are the leading alewife States, although important fisheries also exist in Maine, Rhode Island, Connecticut, Massachusetts, New York, and New Jersey.

The fishing is prosecuted with pound nets, trap nets, weirs, seines, gill nets, fykes, and dip nets; the largest catch is with pound nets and seines. In most States special apparatus is employed, but far the larger part of the yield is obtained with apparatus set primarily for other fishes.

In 1896, according to the investigations of the United States Fish Commission,* over 2,500 persons were engaged in the alewife fisheries, besides many thousand people who operated apparatus in which alewives constituted an important part of the catch. Over 800 people used

*See Report U. S. Fish Commission 1897, pp. CXXV–CXXX.

seines, 930 set gill nets, and nearly 500 fished weirs and pound nets. In the preparation of the catch by smoking and salting 134 persons were engaged. In Maryland there were 616 alewife fishermen, and in Massachusetts 388, while in Maine, Delaware, New Jersey, and North Carolina there were more than 200. The following table exhibits in detail the distribution of the fishermen:

Table showing by States the number of persons employed in the alewife fisheries of the United States in 1896.

States.	Fisheries in which engaged.						Shoresmen.	Total.
	Pound-net, trap-net, and weir.	Seine.	Gill-net.	Fyke-net.	Dip-net.	Total.*		
Connecticut		110	3			113		113
Delaware	2	126	92	2		218		218
Maine	143	10			88	237	10	247
Maryland	114	18	478	6		616		616
Massachusetts	5	223	5		121	342	46	388
New Hampshire	10	5				10		10
New Jersey		193	44			226		226
New York	4	71	28			99		99
North Carolina	145	10	10			165	60	225
Pennsylvania			12			12		12
Rhode Island	28	32				60	18	78
Virginia	20	13	258			288		288
Total	471	811	930	8	209	2,386	134	2,520

* Exclusive of duplication of those in more than one fishery.

The boats, apparatus, and other property which may be credited to the alewife fishery had a value of $111,000 in 1896. This sum represents 1,232 boats, 542 pound nets, trap nets, and weirs, 223 seines, 1,469 gill nets, 70 fyke nets, and 215 dip nets, together with nearly $27,000 worth of shore and accessory property. As may be seen from the following table, the largest investment was in Maryland, where $26,000 were devoted to this fishery, and where more boats, traps, and gill nets were used than in any other State. Massachusetts, Maine, and North Carolina rank next to Maryland in the value of the property connected with the alewife fisheries.

Table showing by States the boats, apparatus, and property employed in the alewife fisheries of the United States in 1896

States.	Boats.		Pound nets, trap nets, and weirs.		Seines.		
	No.	Value.	No.	Value.	No.	Length.	Value.
						Feet.	
Connecticut	31	$683			30	9,987	$2,475
Delaware	101	3,290	5	$150	34	7,933	1,314
Maine	223	3,495	152	8,240	5	1,932	257
Maryland	355	8,683	172	10,160	4	1,920	256
Massachusetts	88	2,974	1	150	45	17,739	3,075
New Hampshire	12	155	12	480	2	360	50
New Jersey	77	2,164			57	30,642	3,025
New York	71	1,488	4	260	26	6,630	1,380
North Carolina	84	2,025	130	6,505	2	2,775	410
Pennsylvania	6	501					
Rhode Island	33	610	18	990	16	9,600	840
Virginia	151	2,139	48	1,435	2	2,100	225
Total	1,232	28,207	542	28,370	223	91,618	13,307

Table showing by States the boats, apparatus, and property employed in the alewife fisheries of the United States in 1896—Continued.

States.	Gill nets.			Fyke nets.		Dip nets.		Value of shore and accessory property.	Total value of invest-ment.
	No.	Length.	Value.	No.	Value.	No.	Value.		
		Feet.							
Connecticut	3	125	$20					$470	$3,648
Delaware	141	41,055	1,346	60	$180			1,795	8,075
Maine						94	$222	5,369	17,583
Maryland	860	141,482	5,561	10	125			1,215	26,000
Massachusetts	10	2,250	120			121	193	12,958	19,470
New Hampshire								355	1,040
New Jersey	183	34,470	784					800	6,773
New York	20	12,780	660					300	4,088
North Carolina	70	2,100	65					3,350	12,355
Pennsylvania	6	5,460	940						1,441
Rhode Island								1,050	3,490
Virginia	176	91,803	3,184					300	7,283
Total	1,469	331,525	12,680	70	305	215	415	27,962	111,246

The alewives taken and sold in 1896 numbered nearly 148,000,000, weighing 62,000,000 pounds and valued at $459,600. The catch in the foregoing apparatus set especially for these fish was much less than in the appliances operated primarily for shad. Thus the alewife fisheries proper yielded upward of 32,900,000 fish, while in the shad fisheries there were over 108,000,000 alewives taken and in other fisheries about 6,400,000. The participation of the different States in the yield of these fish is shown in the table.

Table showing by States the catch of alewives in 1896.

States.	In alewife fisheries.			In shad fisheries.		
	No.	Pounds.	Value.	No.	Pounds.	Value.
Connecticut	2,084,406	742,762	$9,918	173,392	69,357	$580
Delaware	1,434,850	573,940	5,058	622,540	249,016	2,698
Florida				40,000	16,000	400
Maine	4,871,958	2,674,505	20,196	404,781	227,101	2,439
Maryland	4,350,696	1,740,278	11,381	39,752,610	15,901,044	114,489
Massachusetts	7,370,689	3,970,274	35,050			
New Hampshire	479,500	269,734	2,795			
New Jersey	3,410,640	1,915,572	8,170	2,200,350	943,727	5,987
New York	895,070	358,028	4,892	1,422,000	568,800	6,333
North Carolina	1,098,200	439,280	3,062	34,791,598	13,916,640	112,883
Pennsylvania	97,000	48,500	257	1,475,000	590,000	4,115
Rhode Island	3,960,920	1,584,368	23,641	403,200	161,280	692
South Carolina				30,500	12,200	463
Virginia	2,907,070	1,162,828	7,189	27,178,547	10,871,419	55,264
Total	32,960,999	15,480,069	131,609	108,494,518	43,526,584	306,343

States.	In other fisheries.			Total.		
	No.	Pounds.	Value.	No.	Pounds.	Value.
Connecticut	472,625	189,069	$1,533	2,730,423	1,001,188	$12,031
Delaware				2,057,390	822,956	7,756
Florida				40,000	16,000	400
Maine	961,100	486,720	2,701	6,237,839	3,388,326	25,336
Maryland	64,980	25,993	180	44,168,286	17,667,315	126,050
Massachusetts	2,675,237	1,386,215	10,074	10,045,926	5,356,489	45,124
New Hampshire	47,000	23,937	250	526,500	293,671	3,045
New Jersey	733,050	368,775	1,408	6,344,040	3,228,074	15,565
New York	211,470	84,588	1,378	2,528,540	1,011,416	12,603
North Carolina				35,889,798	14,355,920	115,945
Pennsylvania				1,572,000	638,500	4,372
Rhode Island	828,280	331,312	3,551	5,192,400	2,076,960	27,884
South Carolina				30,500	12,200	463
Virginia	408,400	163,360	571	30,494,017	12,197,607	63,024
Total	6,402,142	3,059,969	21,646	147,857,659	62,066,622	459,598

In Massachusetts 7,370,000 were taken—more than in any other State; in the shad fishery of Maryland nearly 40,000,000 alewives were caught; in that of North Carolina nearly 35,000.000, and in that of Virginia about 27,000,000.

The table which follows shows by States the number, pounds, and value of alewives caught with each kind of apparatus. Nearly half of the yield was taken in pound nets, traps, and weirs, and about two-fifths in seines. Only relatively small quantities are obtained with gill nets, fyke nets, dip nets, and other minor apparatus. The largest pound-net catch, amounting to 25,000,000 fish, was made in Virginia; the largest seine catch, aggregating 21,000,000 fish, was in Maryland.

Table showing by States and apparatus of capture the quantity and value of alewives taken in the United States in 1896.

States.	Pound nets, trap nets, and weirs.			Seines.		
	No.	Pounds.	Value.	No.	Pounds.	Value.
Connecticut	506,580	202,651	$1,635	2,204,998	790,999	$10,276
Delaware	71,600	28,640	373	1,732,290	692,916	6,223
Florida				40,000	16,000	400
Maine	2,846,739	1,507,872	14,360	433,500	216,750	1,156
Maryland	21,320,744	8,528,298	45,542	21,178,346	8,471,339	73,185
Massachusetts	2,564,587	1,331,202	9,842	4,949,106	2,629,525	23,440
New Hampshire	481,500	268,359	2,786	45,000	25,312	259
New Jersey	149,550	74,775	505	6,066,540	3,081,974	14,253
New York	254,990	101,996	1,998	1,913,550	765,420	8,925
North Carolina	18,080,214	7,232,086	55,542	16,660,384	6,664,154	54,425
Pennsylvania				1,475,000	590,000	4,115
Rhode Island	1,823,330	729,332	8,771	3,369,070	1,347,628	19,113
South Carolina				2,800	1,120	34
Virginia	25,159,790	10,063,916	49,724	3,208,357	1,283,343	8,039
Total	73,259,624	30,069,127	191,048	63,278,941	26,576,480	223,843

States.	Gill nets.			Fyke nets.		
	No.	Pounds.	Value.	No.	Pounds.	Value.
Connecticut	18,845	7,538	$120			
Delaware	247,500	99,000	1,130	6,000	2,400	$30
Maryland	1,254,336	501,734	5,564	305,860	122,344	1,330
Massachusetts	18,000	10,125	180			
New Jersey	107,200	60,200	646	20,750	11,125	161
New York	360,000	144,000	1,680			
North Carolina	8,200	3,280	68			
Pennsylvania	97,000	48,500	257			
South Carolina				27,700	11,080	429
Virginia	2,119,070	847,628	5,233	6,800	2,720	28
Total	4,230,151	1,722,005	14,878	367,110	149,669	1,978

States.	All other apparatus.			Total.		
	No.	Pounds.	Value.	No.	Pounds.	Value.
Connecticut				2,730,423	1,001,188	$12,031
Delaware				2,057,390	822,956	7,756
Florida				40,000	16,000	400
Maine	2,967,600	1,663,704	$9,850	6,237,839	3,388,326	25,336
Maryland	109,000	43,600	429	44,168,286	17,667,315	126,050
Massachusetts	2,514,233	1,385,637	11,662	10,045,926	5,356,489	45,124
New Hampshire				526,500	293,671	3,045
New Jersey				6,344,040	3,228,074	15,565
New York				2,528,540	1,011,416	12,603
North Carolina	1,141,000	456,400	5,910	35,889,798	14,355,920	115,945
Pennsylvania				1,572,000	638,500	4,372
Rhode Island				5,192,400	2,076,960	27,884
South Carolina				30,500	12,200	463
Virginia				30,494,017	12,197,607	63,024
Total	6,721,833	3,549,341	27,851	147,857,659	62,066,622	459,598

THE FISHERIES CONSIDERED BY WATERS.

In the following series of four tables, the extent of the alewife fisheries in 1896 is exhibited by waters; the first table shows persons employed, the second the boats, apparatus, etc., used, the third the aggregate catch in all kinds of appliances, and the fourth the catch in the apparatus set especially for alewives.

The alewife fisheries of the Chesapeake Basin are seen to have been engaged in by over 900 persons, or more than two-fifths the total number of alewife fishermen, the Chester, Potomac, and York rivers being most prominent in this respect.

Table showing by waters the number of persons engaged in the alewife fisheries.

Waters.	States.	Fisheries in which engaged.						Shoresmen.	Total.
		Pound-net, trap-net, and weir.	Seine.	Gill-net.	Fyke-net.	Dip-net.	Total.*		
Dennys River	Maine	4				8	12		12
Machias River	do	9				34	39		39
Penobscot River	do	73					73		73
Medomak River	do					4	4	2	6
St. George River	do	16				7	23	3	26
Pemaquid River	do					3	3	2	5
Damariscotta River	do	39				4	43	3	46
Kennebec River	do					1	1		1
Casco Bay	do	2	10				12		12
Shores of Maine	do					27	27		27
Newmarket River	New Hampshire	2					2		2
Exeter River	do	8	5				8		8
Merrimac River	Massachusetts		49				49		49
Taunton River	do		87				87	22	109
Ponds, small rivers, and creeks.	do	5	87	5		121	206	24	230
Ponds and small rivers	Rhode Island	28	32				60	18	78
Connecticut River	Connecticut		110	3			113		113
Shores of Long Island	New York	4	36				36		36
Hudson River	do		35	28			63		63
Shores of New Jersey	New Jersey		193	44			226		226
Delaware River	Pa. and Del		8	84			92		92
Delaware Bay	Delaware		5	13			18		18
Indian River	do	2	113	7	2		120		120
Chesapeake Bay and tributaries:									
Bay shores	Maryland	22		287			309		309
Susquehanna River	do		10	10			20		20
Elk River	do	63					63		63
Chester River	do		8	99			107		107
Choptank River	do			12			12		12
Nanticoke River	do			25	4		29		29
Wicomico River	do			22			22		22
Pocomoke River	do			8			8		8
Patuxent River	do	2		7	2		11		11
Potomac River	Md. and Va	26	13	55			91		91
Rappahannock River	Virginia			7			7		7
York River and tributaries.	do			128			128		128
James River and tributaries.	do			76			76		76
Sassafras River	Maryland	21					21		21
Total		134	31	736	6		904		904
Albemarle Sound and tributaries.	North Carolina	145	10				155	60	215
Neuse River and tributaries.	do			10			10		10
Grand total		471	811	930	8	209	2,386	134	2,520

* Exclusive of duplication of those engaged in two or more branches.

The alewife fisheries of the Chesapeake Basin represented an investment of $33,283, of Albemarle Sound $12,270, of Taunton River $12,068, and of Penobscot River $9,888. The use of traps and weirs for alewives was most extensive in the Penobscot and Elk rivers, in each of which 107 of such appliances were in operation. Seines were most numerous in the Taunton, Connecticut, and Indian rivers. Gill nets were used in largest numbers in the Delaware, Indian, Chester, York, and Neuse rivers. The employment of dip nets is restricted to the New England States.

Table showing by waters the boats, apparatus, and other property employed in the alewife fisheries.

Waters.	States.	Boats.		Pound nets, trap nets, and weirs.		Seines.		Gill nets.	
		No.	Value.	No.	Value.	No.	Value.	No.	Value.
Dennys River	Maine	7	$35	2	$265				
Machias River	do	22	110	7	175				
Penobscot River	do	124	2,610	107	6,325				
St. George River	do	16	160	8	480				
Damariscotta River	do	43	439	26	855				
Casco Bay	do	10	131	2	140	5	$257		
Shores of Maine	do	1	10						
Newmarket River	New Hampshire	2	10	3	150				
Exeter River	do	10	145	9	330	2	50		
Merrimac River	Massachusetts	14	1,440			6	830		
Taunton River	do	38	1,147			13	1,478		
Ponds, small rivers, and creeks	do	36	387	1	150	26	767	10	$120
Ponds and small rivers	Rhode Island	33	610	18	990	16	840		
Connecticut River	Connecticut	31	683			30	2,475	3	20
Shores of Long Island	New York	20	520	4	260	20	990		
Hudson River	do	51	968			6	390	20	660
Shores of New Jersey	New Jersey	77	2,164			57	3,025	183	784
Delaware River	Pa. and Del	58	2,211			2	20	56	1,940
Delaware Bay	Delaware	11	165			2	40	9	70
Indian River	do	38	1,415	5	150	30	1,254	82	276
Chesapeake Bay and tributaries:									
Bay shores	Maryland	171	4,748	28	2,280			633	3,257
Susquehanna River	do	9	250			2	180	27	675
Elk River	do	28	1,690	107	5,830				
Chester River	do	70	864			2	76	81	712
Choptank River	do	6	60					18	195
Nanticoke River	do	16	143					16	150
Wicomico River	do	19	108					38	197
Pocomoke River	do	7	40					13	40
Patuxent River	do	8	195	1	15			30	175
Potomac River	Md. and Va	45	1,385	53	1,660	2	225	30	1,634
Rappahannock River	Virginia	6	41					29	62
York River and tributaries	do	69	606					70	954
James River and tributaries	do	38	352					51	694
Sassafras River	Maryland	14	340	31	1,810				
Total		506	10,822	220	11,595	6	481	1,036	8,745
Albemarle Sound and tributaries	North Carolina	77	2,005	130	6,505	2	410		
Neuse River and tributaries	do	7	20					70	65
Grand total		1,232	28,207	542	28,370	223	13,307	1,469	12,680

Table showing by waters the boats, apparatus, and other property employed in the alewife fisheries—Continued.

Waters.	States.	Fyke nets.		Dip nets.		Value of shore and accessory property.	Total value of investment.
		No.	Value.	No.	Value.		
Dennys River	Maine			8	$20	$53	$373
Machias River	do			34	85	365	735
Penobscot River	do					953	9,888
Medomak River	do			4	8	220	228
St. George River	do			7	14	1,361	2,015
Pemaquid River	do			3	6	250	256
Damariscotta River	do			10	20	1,980	3,294
Kennebec River	do			1	2		2
Casco Bay	do					77	605
Shores of Maine	do			27	67	110	187
Newmarket River	New Hampshire					15	175
Exeter River	do					340	865
Merrimac River	Massachusetts					96	2,366
Taunton River	do					9,443	12,068
Ponds, small rivers, and creeks	do			121	193	3,419	5,036
Ponds and small rivers	Rhode Island					1,050	3,490
Connecticut River	Connecticut					470	3,648
Shores of Long Island	New York						1,770
Hudson River	do					300	2,318
Shores of New Jersey	New Jersey					800	6,773
Delaware River	Pa. and Del						4,171
Delaware Bay	Delaware						275
Indian River	do	60	$180			1,795	5,070
Chesapeake Bay and tributaries:							
Bay shores	Maryland					385	10,670
Susquehanna River	do					100	1,205
Elk River	do					375	7,895
Chester River	do					40	1,692
Choptank River	do						255
Nanticoke River	do	8	95				388
Wicomico River	do						305
Pocomoke River	do						80
Patuxent River	do	2	30				415
Potomac River	Md. and Va					300	5,204
Rappahannock River	Virginia						103
York River and tributaries	do						1,560
James River and tributaries	do						1,046
Sassafras River	Maryland					315	2,465
Total		10	125			1,515	33,283
Albemarle Sound and tributaries	North Carolina					3,350	12,270
Neuse River and tributaries	do						85
Grand total		70	305	215	415	27,962	111,246

Among the streams of New England in which alewives are taken Damariscotta River in Maine had the largest catch in 1896, followed by the Connecticut, Taunton, Merrimac, St. George, and Penobscot. In the middle Atlantic region the basin of Chesapeake Bay (in Maryland, Virginia, Delaware, Pennsylvania, and District of Columbia) yielded more than half of the entire catch of the United States. Upwards of one-third of the output in this area was taken in the Potomac, which is now the leading alewife stream of the country. Second in importance is the Susquehanna, after which come the Delaware, Rappahannock, Elk, Hudson, Choptank, and Nanticoke. Albemarle Sound with its tributaries ranks next to the Chesapeake in the production of alewives. More than one-fifth of the aggregate catch of the country is obtained in this section. The Chowan, the principal affluent of the sound, has a very large alewife fishery, ranking next to that of the Potomac in extent.

Table showing by waters the aggregate catch of alewives.

Waters.	State.	No.	Pounds.	Value.
St. Croix River	Maine	11,100	6,243	$93
Dennys River	do	160,500	90,280	470
Machias River	do	91,700	51,581	570
Penobscot River	do	617,608	308,844	3,028
Medomak River	do	73,800	41,512	417
St. George River	do	686,000	385,804	3,014
Pemaquid River	do	206,000	115,875	1,100
Damariscotta River	do	2,472,100	1,390,612	9,811
Kennebec River	do	494,781	277,726	2,739
Casco Bay	do	1,391,250	701,287	3,771
Shores of Maine	do	33,000	18,562	323
Piscataqua River	New Hampshire	47,000	23,937	250
Newmarket River	do	46,350	26,088	270
Exeter River	do	433,150	243,646	2,525
Merrimac River	Massachusetts	945,000	472,500	4,200
Cape Cod Bay	do	1,732,972	884,255	5,479
Taunton River	do	1,897,478	1,067,324	9,478
Ponds, small rivers, and creeks	do	4,528,211	2,430,450	21,372
Shores of Massachusetts	do	942,265	501,960	4,595
Warren River	Rhode Island	403,200	161,280	692
Ponds and small rivers	do	3,960,920	1,584,368	23,641
Shores of Rhode Island	do	828,280	331,312	3,551
Connecticut River	Connecticut	2,216,243	795,497	10,350
Housatonic River	do	4,200	1,680	28
Shores of Connecticut	do	509,980	204,011	1,653
Shores of Long Island	New York	336,540	134,616	2,840
Hudson River	N. Y. and N. J.	2,192,000	876,800	9,763
New York, Sandy Hook, and Raritan bays	do	930,800	465,400	1,374
Shores of New Jersey	New Jersey	3,482,140	1,955,234	8,873
Delaware River	N. J., Pa., and Del.	4,420,700	1,812,980	11,044
Delaware Bay	N. J. and Del.	221,490	88,596	1,589
Indian River	Delaware	550,700	220,280	3,823
Chesapeake Bay and tributaries:				
Bay shores	Md. and Va	24,112,084	9,644,835	61,709
Susquehanna River	Md. and Pa	10,864,000	4,345,600	48,983
Northeast River	Maryland	587,400	234,960	929
Elk River	do	2,327,000	930,800	3,834
Chester River	do	1,219,160	487,664	4,625
Choptank River and tributaries	do	1,993,560	797,424	5,598
Nanticoke River	Md. and Del	1,527,000	610,800	4,339
Wicomico River	Maryland	173,300	69,320	628
Pocomoke River	do	32,730	13,092	223
Patuxent River	do	1,474,330	589,732	4,008
Potomac River	Md. and Va	24,437,885	9,775,154	39,003
Rappahannock River	Virginia	2,798,826	1,119,530	6,411
York River and tributaries	do	632,798	253,119	3,111
James River and tributaries	do	528,230	211,292	2,539
Sassafras, Transquaking, and Blackwater rivers.	Maryland	2,321,600	928,640	4,124
Total		75,029,903	30,011,962	190,064
Albemarle Sound and tributaries:				
Sound shores	North Carolina	11,447,204	4,578,882	34,671
Pasquotank River	do	829,000	331,600	4,167
Perquimans River	do	662,500	265,000	2,126
Chowan River	do	13,559,600	5,423,840	36,715
Roanoke River	do	4,177,000	1,670,800	19,962
Total		30,675,304	12,270,122	97,641
Croatan Sound	North Carolina	1,471,500	588,600	6,565
Roanoke Sound	do	19,400	7,760	81
Pamlico Sound	do	1,137,334	454,934	4,112
Pamlico River and tributaries	do	501,204	200,482	2,374
Neuse River and tributaries	do	2,085,056	834,022	5,172
Pee Dee River and tributaries	South Carolina	10,100	4,040	167
Black River	do	17,600	7,040	264
Edisto River	do	1,800	720	22
Cooper River and Sampit Creek	do	1,000	400	10
St. Johns River	Florida	40,000	16,000	400
Grand total		147,857,659	62,066,622	459,598

The alewife catch in different waters with apparatus set especially for these fishes is shown in the next table. The Potomac River is seen to have the largest yield, closely followed by the Damariscotta, after which come the Connecticut, Taunton, Sassafras, Delaware, Merrimac, Elk, and Hudson.

Table showing by waters the number, weight, and value of the alewives taken in the special alewife fisheries.

Waters.	State.	No.	Pounds.	Value.
Dennys River	Maine	160, 500	90, 280	$470
Machias River	do	91, 700	51, 581	570
Penobscot River	do	606, 158	303, 079	2, 971
Medomak River	do	73, 800	41, 512	417
St. George River	do	686, 000	385, 804	3, 014
Pemaquid River	do	206, 000	115, 875	1, 100
Damariscotta River	do	2, 472, 100	1, 390, 612	9, 811
Kennebec River	do	90, 000	50, 625	300
Casco Bay	do	452, 700	226, 575	1, 220
Shores of Maine	do	33, 000	18, 562	323
Newmarket River	New Hampshire.	46, 350	26, 088	270
Exeter River	do	433, 150	243, 646	2, 525
Merrimac River	Massachusetts	945, 000	472, 500	4, 200
Taunton River	do	1, 897, 478	1, 067, 324	9, 478
Ponds, small rivers, and creeks	do	4, 528, 211	2, 430, 450	21, 372
Ponds and small rivers	Rhode Island	3, 960, 920	1, 584, 368	23, 641
Connecticut River	Connecticut	2, 084, 406	742, 762	9, 918
Shores of Long Island	New York	125, 070	50, 028	1, 462
Hudson River	do	770, 000	308, 000	3, 430
Shores of New Jersey	New Jersey	3, 410, 640	1, 915, 572	8, 170
Delaware River	Pa. and Del	972, 000	398, 500	1, 457
Delaware Bay	Delaware	9, 150	3, 660	35
Indian River	do	550, 700	220, 280	3, 823
Chesapeake Bay and tributaries:				
Bay shores	Maryland	1, 387, 816	555, 126	4, 549
Susquehanna River	do	125, 000	50, 000	430
Elk River	do	900, 000	360, 000	1, 413
Chester River	do	185, 460	74, 184	1, 239
Choptank River	do	18, 000	7, 200	134
Nanticoke River	do	112, 600	45, 040	474
Wicomico River	do	40, 140	16, 056	182
Pocomoke River	do	7, 180	2, 872	62
Patuxent River	do	60, 500	24, 200	159
Potomac River	Md. and Va	2, 713, 000	1, 085, 200	4, 989
Rappahannock River	Virginia	33, 000	13, 200	143
York River and tributaries	do	236, 690	94, 676	1, 534
James River and tributaries	do	217, 380	86, 952	1, 036
Sassafras River	Maryland	1, 221, 000	488, 400	2, 226
Total		7, 257, 766	2, 903, 106	18, 570
Albemarle Sound and tributaries	North Carolina.	1, 090, 000	436, 000	2, 994
Neuse River and tributaries	do	8, 200	3, 280	68
Grand total		32, 960, 999	15, 480, 069	131, 609

COMPARATIVE STATISTICS OF THE CATCH.

In the following table the quantity and value of the alewife catch are exhibited for three seasons separated by intervals of eight years. Some of the States show a larger yield in 1896 than in either 1888 or 1880, and the total output in 1896 is considerably in excess of that for the previous years. In the New England and Middle Atlantic States the increase since 1880 was constant and marked, but in the South Atlantic region there was a smaller catch in 1896 than in the earlier years. Especially noteworthy changes were the increase in Maryland from

9,000,000 pounds in 1880 to over 17,600,000 pounds in 1896, and in Virginia from 6,900,000 pounds in 1880 to 12,197,000 pounds in 1896, and the decrease in North Carolina from 15,500,000 pounds in 1880 and 20,000,000 pounds in 1888 to 14,355,000 pounds in 1896.

Notwithstanding a general increase in 1896 amounting to 16,382,000 pounds over 1880 and 5,908,000 pounds over 1888, the value of catch was less than in either of the earlier years. The average price of alewives per pound in 1896 was 0.7 cent, while in 1888 it was nearly 0.9 cent and in 1880 1.1 cents.

Comparative statement of the catch of alewives in 1880, 1888, and 1896.

States.	1880.		1888.		1896.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
New England:						
Maine	1,804,202	$35,823	3,079,994	$30,103	3,388,326	$25,336
New Hampshire	425,000	8,500	146,750	3,080	293,671	3,045
Massachusetts	3,751,059	35,802	6,291,937	83,530	5,356,489	45,124
Rhode Island	2,978,000	14,460	1,739,300	21,165	2,076,960	27,884
Connecticut	770,000	8,700	125,200	1,253	1,001,188	12,031
Total	9,728,261	103,285	11,383,181	139,131	12,116,634	113,420
Middle Atlantic:						
New York	250,000	3,750	223,000	2,670	1,011,416	12,603
New Jersey	1,200,000	17,335	2,717,520	26,924	3,228,074	15,565
Pennsylvania			811,657	8,365	638,500	4,372
Delaware	2,396,700	30,475	941,986	10,925	822,956	7,756
Maryland	9,128,959	139,667	12,835,524	110,291	17,667,315	126,050
Virginia	6,925,413	76,300	6,757,105	40,369	12,197,607	63,024
Total	19,901,072	267,527	24,286,792	199,544	35,565,868	229,370
South Atlantic:						
North Carolina	15,520,000	142,784	20,463,340	161,673	14,355,920	115,945
South Carolina	400,000	9,000			12,200	463
Georgia	125,000	3,750	24,360	365		
Florida	10,000	200			16,000	400
Total	16,055,000	155,734	20,487,700	162,038	14,384,120	116,808
Grand total	45,684,333	526,546	56,157,673	500,713	62,066,622	459,598

REPORT ON THE OYSTER-BEDS OF LOUISIANA.

BY

H. F. MOORE,

ASSISTANT, U. S. FISH COMMISSION.

INTRODUCTION.

WASHINGTON, D. C., *June 29, 1898.*

On May 6, 1897, the United States Fish Commission received a communication from Hon. Adolph Meyer, M. C., inclosing the following concurrent resolution of the legislature of Louisiana:

Be it resolved by the house of representatives of the State of Louisiana, and the senate concurring, That the United States Fish Commission be requested to investigate in the oyster-spawning season and report to this general assembly before its next session the exact season of the oyster spawning in this State and all other facts respecting the same, and whether or not the present existing laws are not injurious to the oyster industry of this State.

S. P. HENRY,
Speaker of the House of Representatives.
R. H. SNYDER,
Lieutenant-Governor and President of the Senate.
MURPHY J. FOSTER,
Governor of the State of Louisiana.

JOHN T. MICHEL,
Secretary of State.

Pursuant to this request, and in view of the importance of the Louisiana oyster industry, it was decided to undertake an investigation of the subject, and Dr. H. F. Moore, of this Commission, was directed to visit Louisiana in August and September, 1897, for the purpose of making some preliminary inquiries, and the steamer *Fish Hawk*, Lieut. Franklin Swift, U. S. N., commanding, was dispatched to the State in February, 1898, to conduct a more extensive examination of certain oyster-grounds. The accompanying report, based on the investigations thus made, has been prepared by Dr. Moore, who accompanied the vessel and was charged with the consideration of the biological aspects of the work. It was the intention of Lieutenant Swift to write the report on the reconnaissance made by the *Fish Hawk*, but before he could do so he was detached from the Commission and assigned to naval duty.

GEORGE M. BOWERS,
U. S. Commissioner of Fish and Fisheries.

REPORT ON THE OYSTER-BEDS OF LOUISIANA.

By H. F. Moore,
Assistant, United States Fish Commission.

Within recent years several investigations of Gulf coast oyster-grounds have been made by the United States Fish Commission, but none of these related to the waters of Louisiana. Upon the receipt of the request from the general assembly for information concerning the oyster-beds of that State, the writer was ordered to Louisiana for the purpose of determining certain facts relating to the question of close seasons, and to make an examination preliminary to a more careful and extended investigation by the steamer *Fish Hawk* later in the season. A period of about fifteen days in August and September was spent in the oyster regions of St. Bernard, Plaquemines, and Terrebonne parishes, and as a result it was decided to confine the contemplated survey to the St. Bernard region as offering better facilities for the character of work which it was desired to undertake. The *Fish Hawk* was not available until February 1, from which time until February 24, when she left in order to begin her regular work of shad-hatching, the field work was prosecuted vigorously and continuously, except when interrupted by stormy weather.

Owing to the shallowness of the water the *Fish Hawk* could not be used for active duty in the survey, and she was therefore anchored as close as possible to the oyster-beds and used as a base of operation for the launches, at first off the northern entrance to Grand Pass, and afterwards, during the greater part of the work, off the mouth of Three-mile Bayou. The work was often performed at a distance from the ship, and much time was unavoidably lost in running to and from the scene of the day's operations. Should a complete oyster survey of the region be attempted in the future, it could be much facilitated by employing several light-draft vessels, which could be worked into the marshes and used as quarters for the field parties on the launches.

It was originally intended to make a thorough and complete survey of the oyster-beds of St. Bernard Parish similar to that which was made by the *Fish Hawk* in Apalachicola Bay, but this plan was abandoned when it was found that the time at the disposal of the party was to be so limited. Many of the stations established by the Coast Survey have been obliterated or washed away by the storms, and it would have required more time than was available for the entire work to erect and cut in the signals necessary to a proper survey. Contrary to

expectations, it was found that the topography in general had not undergone many important changes since the survey upon which the Coast Survey charts were based, and the several points could be identified and located with sufficient accuracy to suit the purposes of a reconnaissance.

The plan finally adopted was to run lines of timed soundings from point to point, so as to cover the intervening waters by series of intersecting zigzags. As the lines were rarely over 2 miles in length, the position of any given sounding could be approximately determined by its time, the time of beginning and ending the line being noted, and the speed of the launch being nearly uniform on each series of soundings. Most of the important beds were also located by compass bearings from charted points. The charted areas of the beds, as well as their positions, are but approximate; but it is believed that the aggregate is measurably near the truth, although individual beds might prove somewhat greater or less in extent than appeared from the hurried examination which it was possible to make. The soundings were made by means of the sounding pole devised and used by Lieutenant Swift in the survey of Apalachicola Bay, and described in his report upon the oyster-beds of that vicinity. Owing to lack of time no effort was made to determine with exactness the number of oysters to the square yard, as is done in a regular survey, and the terms "dense," "scattering," and "very scattering" are relative in their application to this field only. Dense and scattering beds are such as can be worked with profit by means of tongs. "Very scattering" beds are shown on the chart with some ambiguity—in a few places, especially in the lagoons, denoting a growth, which it hardly pays to work, sparsely distributed over the entire bottom; in other places, as in the northern part of West Karako Bay, representing small beds more or less dense, distributed at irregular intervals, and in the text described as "scattered in patches," or in somewhat similar terms. Such beds can be worked with profit.

The investigation in St. Bernard Parish was under the direction of Lieut. Franklin Swift, U. S. N., commanding the *Fish Hawk*. The hydrographic field work and the location of the oyster-beds was carried on by Mate J. A. Smith, U. S. N., and by Mr. Eugene Veith, of the steamer *Fish Hawk*.

After the *Fish Hawk* concluded the reconnaissance in St. Bernard Parish, the writer was instructed to make an examination of the oyster-grounds of Louisiana west of that region. In pursuance of the latter purpose, he left the ship at Bay St. Louis upon its departure for the north on February 25, and proceeded to several places in Plaquemines Parish, where boats were hired, and all the principal natural beds and planting-grounds were examined. At Grand Isle, on Barataria Bay, a lugger was secured and an examination made of all the oyster-grounds in the vicinity, after which a cruise was made to the westward, under the guidance of men familiar with the region, as far as Morgan City, all of the oyster regions, with the exception of the upper waters of Terre-

bonne Bay, being visited *en route*. No attempt was made to chart or locate even approximately the individual beds examined on this brief tour, but their general character, present condition, and future prospects are reported upon in the following pages.

The writer acknowledges his indebtedness to Col. F. C. Zacharie, Hon. E. McCullom, Hon. Adolph Meyer, and Hon. S. P. Henry for valuable assistance and information, and to Mr. F. F. Hansell for the use of his yacht in visiting the St. Bernard beds in August, 1897.

THE NATURAL OYSTER-BEDS OF ST. BERNARD PARISH.

General description of the region.—The area embraced within the limits of the reconnaissance made by the *Fish Hawk*, and shown upon the chart accompanying this report, does not include all of the oyster-grounds within the parish of St. Bernard. Field work was pushed into the interior waters lying southwest of Indian Mound Bay and Southwest Pass, and known to the oystermen as Treasure Bayou, Mussel Bayou, Flat Bay, etc., but the lack of a chart of this region approaching even approximate correctness has made it seem inadvisable to attempt to plot the oyster-beds found there, though they are described in general terms in the text. South of Drum Bay, in which lie the southernmost of the charted beds, are extensive areas of good oysters stretching to the parish line at Mozambique Point, but these were not examined, owing to lack of time. We were informed that notwithstanding their extent and the good quality of the oysters they were not extensively worked, on account of their inaccessibility as compared with other beds of St. Bernard Parish, and for this reason it was considered that, for the purposes of the investigation, it was not advisable to devote to their examination time which could be more profitably spent in the study of those beds which were in active use and which therefore presented problems of more immediate importance. In this connection incidental mention may be made of the gregariousness and the general lack of enterprise of the oystermen of this district, who, in the latter part of the season, often spend upward of two weeks in loading their boats in Three-mile Bay, rather than leave their fellows and familiar ground to sail 20 or 30 miles to the southward, where they claim they could secure their fares in three or four days.

The district covered by the field work extends from Mississippi Sound on the north as far as Morgan Harbor on the south, and from Chandeleur Sound to the zone where the water becomes of such slight salinity as to be fatal to oyster life. Within the limits of the reconnaissance this zone accords approximately with the meridian passing through Lake Borgne light-house, in Mississippi Sound the oysters extending a mile or two west of that limit, while in the marshes they are all east of the line. The area covered by the reconnaissance was about 200 square miles, comprising a large part of the "Louisiana Marsh." The land is low, rarely rising more than 18 inches above the level of ordinary high water, but in a few cases shell-banks have been thrown up by

wave-action, thus producing the maximum land elevations, in no case, perhaps, more than 3 or 4 feet above tide. During storms the entire land area may be flooded, and in the disastrous hurricane of 1893 it was covered by from 8 to 12 feet of water. The soil is a stiff mud or blue clay, covered with a sparse growth of coarse grasses and scattered tufts of *Salicornia.* Along the bayous there are clumps of mangrove bushes, but with the exception of several crab trees on Mudgrass Island, there is probably not in the whole dreary expanse a plant reaching a height of 10 feet, nor is there a single human habitation.

The land constitutes a low-lying archipelago of irregular islands separated from one another by shallow bays, muddy lagoons, and tortuous bayous, the area of the water being somewhat greater than that of the land. The bayous are of two classes, rather broad, short, deep passes, like Nine-mile Bayou, Three-mile Bayou, and Deep Pass, which serve as the main avenues of tidal flow to and from the interior bays, and long, narrow water-courses which characteristically run lengthwise of the islands, as is seen in the cases of Door Point Bayou, Dead Man Bayou, etc. The bayous of the first class have generally a depth of from 18 to 42 feet, those of the second class from 5 to 12 feet, and all are more or less obstructed by bars across their mouths. The bottoms of the bayous are almost invariably composed of soft mud.

The bays, with the exception of several of those opening into Chandeleur Sound, communicate with the outer waters by narrow mouths. Their floors are comparatively level and, with one or two exceptions, are composed principally of soft mud, with scattered patches of hard mud and sand, usually so small in area as to be negligible in plotting the soundings. The depth of water is generally from 3 to 6 feet, although in some of the bays, particularly those to the eastward, there are channels through which a considerably greater depth can be carried.

The lagoons are very shallow, small-mouthed, blind bays, like Blind Pass and Grecque Bayou, with soft bottoms largely exposed as mud flats at low water.

Blind Pass, Nine-mile Bayou, and False-mouth Bay.—Blind Pass marks the western extension of the oyster in the marshes on the south side of Mississippi Sound. It is a shallow lagoon communicating on the north with Mississippi Sound, on the east, by a narrow but deep cut, with Nine-mile Bayou, while to the southward a tortuous bayou establishes communication with False-mouth Bay. It consists largely of a mud-flat, exposed at low water, with oysters of rather inferior quality sparingly scattered over the bottom.

Nine-mile Bayou is about 2½ miles long to its main entrance into False-mouth Bay and has a width of from 100 to 300 yards. At its mouth there is a depth of about 18 feet, which rapidly shoals outwardly to 6½ or 7 feet. In the bayou the depth ranges from 17 to 39 feet, the average being about 24 feet. The bottom is soft, excepting that portion lying opposite the small island at the southern end, where hard mud was found. There are no oysters in this bayou.

False-mouth Bay covers about 11.3 square miles. It connects with Mississippi Sound by means of Nine-mile Bayou, and to the eastward opens by a wide mouth into the passage between Raccoon and Mud-grass islands. The bottom is composed of hard mud of a somewhat clayey character, resembling that on the surrounding islands. The depth is almost uniform, in the northeastern part being from 3 to 3¾ feet and elsewhere from 4 to 5 feet. The density in the middle of February varied from 1.0048 to 1.0066 in the several parts of the bay, the temperature at the same time ranging between 16.5° C. (61.7° F.) and 19° C. (66.2° F.). The water is less saline than elsewhere in the marsh, owing to its proximity to the main sources of fresh water, the Pearl River and the discharge from Lake Pontchartrain.

There are very few oysters in False-mouth Bay, and those discovered by the reconnaissance were found fringing the three islands shown on the chart, as a scattering growth of single oysters of fine shape, round, deep, and about 6 inches long. The amount of young growth was small, a few oysters about 2 to 2½ inches long being found attached to the old ones, to clam shells, and lying singly on the mud. A very small amount of spat was attached to the clam shells which fringe the north-east shore of the southernmost island. All of these oysters, both large and small, were extremely fat, but their flavor was insipid owing to the low salinity of the water. The oystermen state that the oysters are always fatter here than on the beds to the eastward, and that they are kept "cleaned up" by the boats which aim to carry the best oysters to the New Orleans markets. It is the custom of the oystermen to paddle around the shores when the water is clear and smooth and pick up with nippers the oysters which can be clearly seen. In December, 1897, a small bed was found in the northern part of the bay, but a number of boats went to work upon it and within a few days it was reduced to a state of practical extinction and we were unable to find any remnant of it.

An examination of the bottom by means of the dredge and tangles showed it to be remarkably clean and free from débris of all kinds. A few crabs of small size, several species of lamellibranchs, and numerous worms were the only living forms found on the hard bottom. Enemies are probably extremely rare, although it is possible that the drumfish might cause damage upon beds of planted oysters. The conch was not found at all, although it is not uncommon in the neighboring waters of Three-mile and Nine-mile bays. The boring-clam (*Martesia*) is common, but it is less abundant than in the more saline waters, and in any case it would not prove detrimental to the oyster.

It seems probable that the scarcity of oysters in False mouth Bay is due in a large part to the lack of suitable places of attachment for the spat, and if this be so there is but little doubt that productive beds might be established by planting shells, together with a sufficient number of brood oysters to furnish fry. We found here the largest area of firm bottom discovered anywhere within the limits of the recon-

naissance. In most other parts of the district the hard bottom is distributed in small patches, lying like islands in the midst of soft mud, but in False-mouth Bay the shells and seed could be deposited almost anywhere without danger of becoming engulfed. The amount of oyster food is larger than almost anywhere else in the district, the average number of diatoms in each liter of water 1 foot above the bottom being about 22,000. The extreme fatness of the oysters is also ample evidence of the abundance of food, although, of course, the amount available for each individual would become less if planting were extensively undertaken. The chief drawback to planting lies in the low salinity, which, as before stated, detracts from the flavor of the oyster, and if not corrected during the spawning season would also militate against the production of young. Without doubt, however, there is an increase in the density during the late spring and summer, when fry abound. Material to serve as cultch or collectors for the attachment of the young oysters might be obtained from the island in the extreme southern part of the bay, where the shore is covered by a mass of clam shells more or less finely broken up. The smaller particles of shells are too small for use, as the action of the storm waves in the shoal waters of the bay would tend to carry them away; but many of the shells are entire, and these, together with the larger fragments, should make excellent cultch.

Nine-mile Bay.—This body of water lies east of Pirate Point and west and northwest of Raccoon Island. It is continuous with Three-mile Bay to the eastward, and in its northwest corner it communicates with Nine-mile Bayou by a channel in which the depth varies from 10 to 21 feet.

North of Nine-mile Bay and in communication with it lies South Bayou, a lagoon-like body of water, very shoal and with no oyster-beds. The depth of water in the bay is between 4 and 5 feet, and the bottom is composed principally of soft mud. The density on February 14 was about 1.0060, and the temperature at the same time was about 17° C. (62.6° F.). The oysters are obtained principally in the eastern part, between Raccoon Island and the opening to South Bayou, being generally single, much scattered, and of rather good shapes. These beds, like those in Three-mile Bay, are much worked, and late in the season are composed principally of cullings. There is a small bed of scattered oysters just off the southeast point of Pirate Point, which appears to have been established, or at least largely sustained, by artificial means as a result of bedding oysters for "fattening" purposes, the culled young growth and shells being carefully returned to the water to serve as seed and cultch, the product of which becomes available for market in subsequent seasons. This place is claimed by oystermen to possess remarkable properties as a fattening-ground, but as the oysters are brought from the denser waters to the eastward and exhibit their improvement within 24 hours from the time of bedding it is probable that the process is one of bloating rather than of fattening.

small bed of oysters is found in the southeastern branch of Nine-mile Bayou, about the middle of the second reach from Nine-mile Bay, on the west side of the channel. It is from 30 to 50 yards long, and extends to about the middle of the bayou. It contains some single oysters of good shape and quality and many dead shells.

Three-mile Bay.—Three-mile Bay is the most important oyster region in St. Bernard Parish, not because its beds are more extensive than those of other parts of the Louisiana Marsh, but because of its accessibility from New Orleans and the cities on Mississippi Sound. Nearly all of the boats enter the marsh at Three mile Bayou, whatever may be their ultimate destination, and it is to this place also that oyster-freighters resort to secure their fares from the luggers and other craft engaged in the active work of oystering.

Three-mile Bay lies between Three-mile Bayou (by which it communicates with Mississippi Sound) on the north and Raccoon Island on the south, its eastern and western limits being Nigger Point and Shell Point, respectively. It covers an area of about 7.3 square miles. In Three-mile Bayou the depth of water reaches a maximum of about 40 feet, the channel gradually shoaling as it enters the bay, over the greater part of which the depth ranges from 4 to 6 feet. In some places a depth of 3 feet or less is to be found, but in general such shoal spots are less common than in West Karako Bay. The average density of water during February was about 1.0065, and the temperature was about 17° C. (62.6° F.).

The bottom is composed of mud of varying degrees of softness. There are a few small areas of hard bottom, but these are principally upon old oyster-reefs, and are now used by the oystermen as beds on which to deposit their catch pending the completion of their cargoes. The softest bottom is found in the southern part of the bay near Raccoon Island, where the mud is entirely too soft to utilize for planting, but places in the center of the bay might be used, although on account of the danger of suffocation in the mud the oysters could not be planted very thickly. The amount of oyster food contained in the water is large, and, especially in the northern part of the bay near the inlet, the currents are comparatively strong. Originally, we were informed, the natural oyster-beds in this bay were dense and extensive, but as a result of the persistent "working" to which they have been subjected during the past few years the dense, well-defined reefs have entirely disappeared, and have been replaced by a scattering growth of more general distribution. The clusters are kept broken up by the process of culling, with the result that the separated oysters show considerable improvement in shape, condition, and flavor over their original state. They are usually either single or in clusters of from two to four; they are rather elongate, moderately fat, of fair flavor, and comparatively free from extraneous growths, such as mussels and algæ. On the very soft mud near Raccoon Island, in the southern part of the bay, the oysters are extremely long and in clusters overgrown with mussels.

Early in the season and until about January or February there is a rather large proportion of marketable oysters, but later these become caught up, leaving practically nothing except dead shells, spat, and young growth. This was essentially the condition of the beds at the time of our examination, and after the middle of February it took about three times as long to catch a barrel of oysters as it did early in the season, and in the latter part of the month most of the fleet which had been oystering there were forced to move farther into the interior. By the time the next season opens many of the young oysters which have been culled off will have reached a suitable size for market, and the providence of one year thus insures the plenitude of the next. Were it not for the moderate care with which the oysters are culled and the young ones and the dead shells returned to the beds whence they were taken, it is impossible that these beds should have so long sustained the demands made upon them. Were it the custom here, as it is in certain other parts of the State, to carry off the young for seed, the phenomenon of the annual recuperation of beds previously exhausted of their marketable stock would not be witnessed.

Not all of the boats cull their catch as carefully as they should. Those which carry their oysters to New Orleans and other markets for sale as "shell stock," from motives of self-interest exercise due care, for imperfectly cleaned and separated oysters bring a lower price than those which are well culled and free from extraneous growths of barnacles, mussels, and young oysters. The chief difficulty is with those boats which catch oysters for the canneries, located principally without the State, where the presence of small oysters is not objectionable.

It is reported that dredges have worked in Three-mile Bay, but the conditions are such that it is probable that this practice was never extensive.

West Karako Bay.—West Karako Bay embraces about 9 square miles, included between Crooked Island and the land masses embracing Johnson Bay and its connections, and between the Raccoon Islands and Shell Island. Its greatest extent is east and west. The bottom resembles that of Three-mile Bay, being composed principally of soft mud with patches of hard mud at wide intervals. The depth over most of the bay ranges from 4 to 6 feet, but there is a maximum depth of 8½ feet in the channel running from Dead Man Island to the cut north of Shell Island, and there are also a number of shoal spots upon which the depth is less than 3 feet, these shoals usually being covered with oysters. The average density of the water is about 1.0065.

The oyster-beds in this bay are more extensive than in Three-mile Bay, and there are also several well-defined reefs which can be characterized as dense. One of these lies south of Dead Man Island and two others lie west of Shell Island, about opposite its northern and southern points, respectively. The oysters on these reefs are of moderate size and in clusters of from 6 to 20. North, northeast, and east of Dead

Man Island, as far as the mouth of Picnic Bayou, are patches of scattered oysters in clusters. No attempt is made to indicate either their size or location on the chart, although they are shown *in toto* over the area mentioned. There are other beds of scattering growth, the limits of which are better defined, and these are plotted with some approximation to correctness. All of these oysters are of the same general character, being in clusters of from 6 to 20, rather thin-shelled and elongate, approaching in general the raccoon type, and in some parts of the bay they appear to be more or less imbedded in the mud. They are to some extent clothed with brown alga, especially in that part of the bay lying east of Dead Man Island, and many of the clusters bear a few mussels and barnacles. The amount of young growth is large. At the time of the examination most of these oysters were but moderately fat, and some of them were quite poor. They show many of the features exhibited by virgin beds, and their quality would doubtless be improved by more extensive working, provided that proper culling methods were practiced. West Karako Bay is resorted to by a number of boats, especially by those engaged in taking oysters for the canneries, and late in the season, after the beds of Three-mile Bay become depleted of their more desirable oysters, some of the oystermen engaged in the "shell trade" also work there.

Johnson Bay and Johnson Bayou.—Johnson Bayou is about 2 miles long, communicating at its southern end with an intricate series of bays and lagoons lying north of West Karako Bay. At the entrance from Mississippi Sound the depth of water is about 6 feet, but inside it deepens to 12 or 14 feet toward the west bank. The bottom is composed of very soft mud. It contains a very scattered growth of oysters throughout its length.

Johnson Bay is the easternmost and largest of the several bodies of water communicating with the bayou. It contains about 1.3 square miles. The bottom is principally soft mud, and the density was about 1.0062 during the first week in February.

There is a scattering growth of good oysters all around the shores, and a few also occur in the middle, where there is also an old, exhausted reef, the crest of which is dry at low water. It is about 150 yards long and 100 yards wide, and it constitutes the most extensive area of hard bottom in the bay. It could be utilized to advantage for planting. At the time when this bay was examined there were seven schooners oystering there, the captain of one of which stated that the oysters were much scarcer than formerly and that it took him from 10 to 17 days to get a load of 120 barrels. The oysters are gathered by small boats, of which each schooner has several, which go into the small bayous and alongshore, where they pick them up in the shoal water.

In the southern part of the irregular bays west of Johnson Bay there is a bed of scattered oysters on the soft mud in a depth of from 1 to 3 feet. They are generally in clusters of from 3 to 15, mostly of medium size, with a good growth of young oysters and some spat,

and more or less overgrown with mussels. It is stated that there is a scattering growth all over the irregular lagoons to the northward. The density on the bed examined was 1.0066.

East Karako Bay, Northwest Jack Williams Bay, and Picnic Bay.—East Karako Bay lies between Shell Island and Deep Pass, the former separating it from West Karako Bay and the latter placing it in communication with the waters of Chandeleur Sound. It embraces about 7.4 square miles, its greatest extent being in a north-and-south direction. In the northern half of the bay the depth varies from 2½ to 4 feet, the bottom being composed principally of soft mud, often mixed with sand. Along the southern side of the island in the northern part, there is considerable hard mud and sand interspersed with soft mud, and also a few patches, more or less limited in extent, in other places. In the southern half of the bay the water averages somewhat greater in depth, being from 4 to 7 feet. A channel runs from the northern point of Shell Island toward the mouth of Deep Pass, the water reaching a maximum depth of 16 feet near the point projecting into the southern end of the bay, and there is also some deep water near the upper entrance to Deep Pass. In this part of the bay the bottom is composed of soft mud almost exclusively. The amount of oyster food is very great.

In East Karako Bay there are about eight oyster reefs which are either awash or exposed on their crests at low water. On and near these crests the bottom is invariably hard, being composed of a macadam of sand and ground-up clam and oyster shells closely compacted, with entire shells lying upon the surface. As a rule these ridges are long and narrow in their exposed portions.

Near the crests of the reefs there is usually a scattering growth of young oysters about 2 to 2½ inches long, together with a few large ones, and considerable quantities of spat are attached to the dead shells, which, from the combined action of the sun and waves, are usually bright and clean and admirably suited to serve as cultch. The young-growth oysters are usually single or in small clusters, and are well-shaped and flinty-shelled. Away from the crests of the reefs the bottom becomes gradually softer, finally merging with the surrounding mud, and as the bottom changes there is also seen a modification in the characters of the oysters. They occur in larger clusters, usually containing from 6 to 10 adult individuals; the shells lose their flintlike appearance and become dark brown and more or less overgrown by a dark-brown seaweed, which appears to be especially abundant in the southern part of the bay. These oysters are invariably flat, thin-shelled, and the largest of them are usually not more than 5 inches long. Excepting a bed off the long point on the eastern side, all of the oysters in East Karako Bay are inferior in fatness and flavor and are rarely taken by the oystermen. They mark the extreme condition toward which those in West Karako Bay indicate a tendency, and no doubt represent the primitive state of most of the oyster-beds of this region. If these beds were

worked, there would doubtless result an improvement in the quality of the oysters, due to the breaking up of the clusters and the thinning out and better distribution of the individuals. It would be distinctly advantageous if many of these oysters could be gathered as seed and planted elsewhere, under restrictions advocated in the recommendations attached to this report, thus producing not only an improvement in the character of the plants, but also in the environment of those left upon the natural beds.

There are several places in the bay where the growth is quite dense, and over considerable areas there is an average of from 6 to 8 clusters of from 3 to 8 adult oysters each per square yard. Surrounding these, and more or less connecting one dense area with another, there are scattered clusters lying on the soft mud. The comparatively few oysters taken from the beds in this region are used exclusively for steaming, and the alga, which often grows in luxuriant tufts on the shells, detracts from the value of the oysters for this purpose, as it is extremely difficult to prevent its filaments from becoming mingled with the "meats."

Northwest Jack Williams Bay is a northern extension of East Karako Bay, and it bears the same general characteristics as are found in the northern part of the latter. Its density is about 1.0110, the depth of water is from 2½ to 3½ feet, and the bottom is largely composed of soft mud. Two beds of oysters were found—one in the center of the bay, where there are scattered clusters on the soft mud, and another around a shell island in the eastern part, the latter resembling the exposed reefs described above. There is also a scattered growth along the southwest shore.

Picnic Bay extends westward from the bay just described, and at the strait connecting the two is a small bed of oysters which extends for some distance into the southern part of Drum Bayou. There are also a few oysters scattered all over the bay, the mud there being very soft, with a number of dead shells imbedded beneath the surface. They are long, narrow, and sharp-edged, and grow in clusters, bearing mussels, barnacles, and tunicates. The shells frequently contain dark vesicles filled with black mud. The density in this bay was several degrees lower than in the neighboring water, being but 1.0070. The depth rarely exceeds 2½ feet.

Drum Bayou and Turkey Bayou.—Drum Bayou is a long, narrow channel leading from Mississippi Sound southward to Picnic and Northwest Jack Williams bays, and giving off a branch westward to Turkey Bay. The depth of water ranges from 5 to 10 feet, with about 3 feet on the bar across the mouth. The density is about 1.0105 and the bottom is mostly soft mud. There are some large single oysters in the channel, together with many dead shells and some young growth, and at low water occasional large clusters of raccoon oysters are exposed along the banks. The oysters in the channel are rather long and narrow, but at the time of examination were in fair condition and of good flavor. The creek leading into Turkey Bayou possesses the same gen-

eral features as the main stream, but has a depth of from 1 to 3 feet. It contains oysters of fair quality, both single and in clusters of from 3 to 10, some of them being very large.

In Turkey Bay, the large lagoon discharging through Turkey Bayou, the depth of water varies from 2 to 6 feet, the bottom being generally soft and muddy and the density about 1.0076. There are three areas of scattered oysters, one lying in the channel between the eastern shore and a small island, another being about a quarter of a mile from the entrance to Turkey Bayou, and the third beginning opposite the channel opening to the westward and extending southward for about three-eighths of a mile. The latter bed is the largest of the three, and near the mouth of the creek there are some oysters, of good size and quality. This creek also contains a scattered growth of oysters, which becomes dense in the branch running to the northward, where the oysters are large and fine.

Grand Pass, Bayou Grecque, and Shrimp Bay.—Grand Pass (Oyster Bay) has an area of about 1.8 square miles. It opens on the north into Mississippi Sound and on the southeast toward Chandeleur Sound. The depth is generally between $2\frac{1}{2}$ and 5 feet, but deeper water occurs on the west side of the small island in the northern part of the bay, where soundings of from 12 to 16 feet were found. Excepting in the vicinity of the oyster-reefs and in places along the shore, the bottom is composed of deep soft mud. The density during the first week in February averaged about 1.0100 and the temperature was about 10.5° C. (50.9° F.).

There are eight oyster-reefs in the eastern part of this bay, several of them being partially exposed at low water. A scattering growth of marketable oysters also occurs in the shoal water along the eastern shore, and on the middle third of the western shore we found a corresponding development of young growth. In the latter locality every shell or other hard body in the water has young oysters attached to it in clusters, and there is no doubt but that by exposing suitable cultch around the edge of the marshes, as is done at Bayou Cook and Whale Bay, important and productive spatting-grounds could be established and a supply of seed thereby secured which would be independent of the natural beds. It is stated that considerable quantities of oysters were to be found formerly in the center of the bay, but that they had been exterminated by the dredges which operated there. At present there are practically no oysters and very few shells to be found away from the shores and reefs, but there is, of course, no indication of the means by which they were caught up if they ever existed in other parts.

Oystering here appears to be confined to the vicinity of the exposed reefs and the shoal water along the eastern shore. The oysters at the time of our examination were rather poor in shape, of moderate size, and inferior in flavor and fatness. They are usually found in small clusters. The conch is the most troublesome enemy with which the oysters have to contend in this vicinity. It is rather more common

and destructive here than in the waters farther removed from Mississippi and Chandeleur sounds.

In the extreme southern part of the bay there is a very scattering growth and in the mouth of Jack Williams Bayou there occurs a bar of raccoon oysters, partially exposed at low water. Raccoon oysters also occur along the shores between tide marks throughout the length of the bayou and in the small, muddy ditches opening into it, and in the channel are scattered clusters of oysters which are fairly fat and superior in flavor to those which are found on the beds of Grand Pass.

From the southwest part of Grand Pass a tortuous, narrow, and in some places deep, bayou leads south to a series of shoal lagoons, the entire chain constituting Grecque Bayou. The lagoons have an average depth of about a foot, with a few holes 2 to 3 feet deep in places, and extensive mud-flats around the margins. The bottom is usually very soft. The density varies from 1.0107 in the ponds near the entrance to 1.0119 in those at the end of the chain, the flow of water through the long, narrow communication with Grand Pass being apparently insufficient to compensate for the increased evaporation on the shallow mud-flats. Over the greater part of these lagoons there is a very scattering growth of large and rather good oysters on the mud, and there is also a scattering fringe of raccoon oysters on the edge of the marsh. The oysters in Bayou Grecque are taken by small boats and carried to the schooners in Grand Pass.

Shrimp Bay and Southeast Jack Williams Bay.—Shrimp Bay lies southeast of Grand Pass, with which it has direct communication by means of the upper part of Jack Williams Bayou. Its depth varies from 1 foot in the northern and eastern parts to about 4 feet at the southern end, where it opens into Southeast Jack Williams Bay, together with which it has an area of 1.7 square miles. Its density on February 3 was 1.0096. This bay contains five oyster-reefs, exposed at low water, with a scattered growth of oysters surrounding each. Near the reefs the bottom is hard from the accumulation of ground-up shells and sand, but elsewhere it is soft, and in the northern half of the bay with a hard substratum of dead shells about a foot beneath the surface. This portion of the bay appears to have been at one time an extensive oyster-bed, which has been largely destroyed by an accumulation of mud thrown down, some of the oystermen claim, by the great storm of 1893, and the reefs, which have been already mentioned, and several patches of oysters along the northeast shore, are now all that remain. There are also oysters in the bight on the eastern side of the bay, scattered more or less sparsely over the mud-flats and near the small islands forming an exposed bar.

Upon the reefs the oysters are small and of the clustered raccoon type, but in the slightly deeper waters surrounding them there are some single oysters of good shape, but not very fat. In Southeast Jack Williams Bay, which consists of a larger western and a smaller eastern arm, there are very few oysters, although the presence of shells

beneath the surface of the mud indicates the submergence of beds formerly existing there. In the eastern branch there are a few shells lying on the surface of the mud, and in the lagoon at its southern end there are raccoon oysters along the banks and a few clusters in the channel in about 5 feet of water.

In the bay the depth is from 2 to 3 feet, the bottom being composed of soft mud. The density in the eastern arm was 1.0107 and in the western 1.0094.

Cranetown Bay.—This bay, which lies between West Karako Bay and Southwest Pass, has an area of 2.7 square miles and a depth of between 3 to 6 feet, except near the mouth of Elephant Pass, a broad bayou having a maximum depth of 30 feet, by which it communicates with Chandeleur Sound. The bottom over most of the northern and eastern parts of the bay consists of soft mud, except upon and near the exposed crests of the reefs, but toward the middle of the west shore there is a considerable area of hard mud and sand. Being in such intimate connection with the outer waters via Deep Pass and Elephant Pass, it is not surprising to find that the water here is denser than on most of the other oyster-beds of St. Bernard Parish, ranging from 1.0139 to 1.0163. The amount of oyster food, as measured by the number of diatoms, is small. The currents are rather strong.

In the northern part there are several dense beds of oysters, which have their crests bare or awash at low water. Surrounding these, as well as on the west side, there is a scattering growth of oysters in clusters. In general character these beds resemble those of East Karako Bay, the oysters being inferior both in shape and flavor. Near the crests of the reefs there is a considerable quantity of young oysters in small clusters attached to dead clam and oyster shells.

On the northeast shore, in the small bay between Deep Pass and Elephant Pass, there is a bed of scattering oysters in small clusters. These are of fair size and fatness, and in general somewhat superior to the other oysters in the vicinity. A scattering growth of rather large oysters and many dead shells are found in the mouth of the bayou opening into the southwestern part of the bay. These are the fattest and best oysters in the vicinity.

Kerchimbo Bay lies west of Cranetown Bay, with which it communicates by the bayou just mentioned. It opens southward into Southwest Pass, westward by an artificial cut into East Karako Bay, and northward into the same bay by a bayou containing a few good-sized oysters and many dead shells. The depth of water is about 3½ feet, excepting near its upper end, where there are barely 2½ feet in the channel. It contains several old reefs composed of dead shells and a scattering growth of rather poor oysters of medium size. According to the testimony of the oystermen there are good oysters scattered all over Kerchimbo Bay, but the reconnaissance did not discover them.

Southwest Pass.—This is a long, narrow body of water stretching from Cranetown and Kerchimbo bays on the northeast to the entrance

to Drum Bay on the southwest. It is about 9 miles long and its width varies from $\frac{1}{3}$ to $1\frac{1}{4}$ miles, the average being about $\frac{3}{4}$ mile. The area is about 7.9 square miles and the depth is generally between 3 and 4 feet, although deeper water is found near the island in the center and some of the oyster-beds are in a depth of less than $2\frac{3}{4}$ feet. There is considerable hard bottom, and in the southern two-thirds hard mud is the predominating characteristic. The density is somewhat greater in the northern part of the bay, where it averages about 1.0120 as compared with an average of 1.0084 in the southern part, this difference appearing to be due to the closer communication with the exterior waters in the north and with the interior bays and bayous, by way of Catfish Pass, in the south. The water contains a fair amount of oyster food, more than Drum Bay but less than either East Karako or Indian Mound bays, which lie to the north and west, respectively. There are good marketable oysters distributed throughout practically the entire length of Southwest Pass. In most cases the growth is scattering, but north of the island, near the center of the bay, is a reef, on which there is a dense growth of small oysters in clusters, together with a few good ones of medium size and some dead shells. This appears to be an old reef, from which the marketable oysters have been nearly all removed, but its condition is such that it will again be productive within a year or two. There is a scattering growth of oysters, in clusters of from 3 to 5, extending eastward from the denser portions of the bed.

A scattering growth also occurs near the shores of the island, and just south of it there are small patches distributed over the bottom, none of them being extensive enough to be called a bed, but constituting in the aggregate quite a large body of oysters. In the southern half of the pass there is a growth along shore on both sides of the channel, where the oysters are in clusters, much scattered, and all of fair quality. These beds appear to be rather extensively worked, and it is said that large quantities of oysters have been taken from there to the markets and that prior to the Nita crevasse in 1890 they had been almost exterminated by excessive tonging.

Drum Bay.—Drum Bay lies southeast of Southwest Pass, with which it communicates by a broad pass at the western end. Including the waters as far east as Keelboat Pass, the bay embraces about 12 square miles. North of Drum Bay, and separated from it by a long, irregular island, there are two shallow bays having together an area of about 1.7 square miles. The water in Drum Bay is from $3\frac{1}{2}$ to 6 feet deep, the general depth being greater to the eastward, where, between the two islands lying northwest of Keelboat Pass, there are 19 feet of water in one place. In the composition of the bottom hard mud predominates, but it is interspersed with areas of soft mud. The density varies from 1.0101 near the western pass to about 1.0150 in the eastern part, near Keelboat Pass. The amount of oyster food, as determined by an examination of the water, appears to be small.

There are oysters scattered all over this bay as far as the entrance to Chimney Bay. There is one very dense bed about ½ mile long and ¼ mile wide lying near the center of the bay, and northwest of it lies a smaller reef, where the oysters are equally dense. Upon these beds the oysters are in clusters of from 3 to 10, of the raccoon type, poor in shape, condition, and flavor. These beds are not worked and there are about 18 inches of water on their crests at low tide. There is a scattering growth of oysters over a large part of the bay to the westward of the reefs just described, especially along the shores, and lying across the narrowest part is a bed of clustered oysters of fair quality. The best oysters, so far as flavor and condition are concerned, are found on a small bed northeast of the entrance to Chimney Bay, but the growth there is very scattered and the bed is apparently nearly exhausted.

A dry shell-reef lying north of this bed is now extinct as an oyster-ground, being composed entirely of dead shells, and it is stated that a bed of excellent oysters formerly existed between the two islands to the eastward, but that it was exterminated a number of years ago by tonging. No indication of it now remains.

In Julius Pass, in some parts of Scow Pass, and in Chimney Bay there are, according to the statements of the oystermen, a few scattering oysters, but except the former these waters were not examined. There is a scattering growth in the two bays north of Drum Bay, where the water is very shoal and the bottom muddy. The amount of young growth in Drum Bay is fair. The clusters are overgrown to a slight extent with algæ, barnacles, and mussels.

California Bay.—In the head of California Bay the depth varies from 3 to 5 feet and the bottom is composed almost entirely of hard mud. Excepting at the mouth of Dead Man Bayou, there are no oysters, but several beds of dead shells were found. At the mouth of the bayou there is a scattering growth of fine, large, single oysters of excellent flavor and fatness. Formerly such oysters were found throughout the bayou, and we were informed that in the winter of 1896–97 about 2,000 barrels were carried away from this place, and our soundings and examination showed that practically none are left.

Fox Bay contains a few scattering oysters near its eastern end, and there is a small bed in Redfish Bend near Elephant Pass.

Indian Mound Bay.—This is the largest body of water in the Louisiana Marsh and it contains more good, marketable oysters than any other of the bays within the limits of this reconnaissance. It lies between Crooked Island and Catfish Pass and between Mudgrass Island and the long island forming the western side of Southwest Pass. Its area is about 21 square miles and its depth averages about 4 feet and ranges between 3 and 5 feet. Its density is least in the northwestern part and greatest in its southern part, as may be seen from an inspection of the chart; the average for the entire bay was about 1.0070, somewhat greater than in West Karako Bay and less than in either East Karako Bay or Southwest Pass, with all of which it is in communication. The amount of oyster food in the water is large.

Practically the entire shore of this bay is fringed with oyster-beds, and there is besides a scattering growth around the islands in the middle. In the northeastern part, between Crooked Island and Mudgrass Island, there is a dense bed about $\frac{3}{4}$ mile long by $\frac{3}{8}$ mile wide. The oysters on this bed are of good size, single and in clusters, and quite fat, although the flavor at the time of examination was poor, owing to the low salinity of the water. In the northeast corner of Indian Mound Bay, there is another bed of dense growth extending in a northeast and southwest direction for about $1\frac{1}{4}$ miles, with a maximum width of about $\frac{5}{8}$ mile, and running off westward into a scattered growth of considerable extent. This bed constitutes the largest single body of good oysters in the region covered by the reconnaissance. They grow principally on the mud bottom, in clusters of from 3 to 10, their upper valves being dark with broad coriaceous edges, which usually indicate rapid growth, the lower valves being flinty and sharp-edged. Notwithstanding the deneness of this bed, the oysters are generally fat and in good order, and the flavor is excellent. There is some growth of alga on the clusters here, but it is much less luxuriant than on the beds of Karako Bay. Taking into consideration the abundance and character of the oysters on this bed, it is but little frequented by the oystermen, not more than two or three vessels being seen upon it at any time during our visit. South of this bed is another dense body of oysters of somewhat similar character, but smaller in extent. On both beds there is an abundance of young growth and spat.

Near the middle of the northern part of the bay lies another dense bed, fringing a long, narrow reef exposed at low water. The oysters here are mostly in clusters and covered with a considerable growth of alga, mussels, and barnacles. Most of the other oysters in this bay are more or less scattering, but in the extreme southern part, just north of Catfish Pass, there is a dense bed of good oysters surrounded by a considerable area of more scattered growth. Several vessels were oystering here, and a considerable quantity of oysters is caught late in the season, after the beds of Three-mile Bay and vicinity have become somewhat exhausted.

North and west sides of Mudgrass Island.—These shores are largely composed of very soft, deep mud, a condition which has a very palpable effect upon the character of many of the oysters, which assume an extremely narrow, elongated form, and grow in inverted pyramidal bunches, the lower members of which are immersed in the mud. On the north shore there are three areas of dense growth. Two of them are situated near the northwestern point of the island, on moderately hard mud, the oysters being large and single or in small clusters, with an abundance of spat attached. The third bed lies in a deep bay near the western end of the north shore, close to the point the oysters being of fair shape and quality, but on the soft bottom which constitutes by far the greater part of the bed they are long, narrow, and sharp-edged as described above.

Near the middle of the west side of the island, lying in a cove, is a dense bed of rather good, large oysters on hard bottom. There are few barnacles here, but mussels are abundant. The rest of the oysters on the west side of the island are of the kind described as characteristic of the soft bottom.

Treasure Bay, Mussel Bayou, and vicinity.—The waters included under this heading, except a portion of Treasure Bay, are not shown upon the accompanying chart, inasmuch as a proper survey has never been made. They embrace an intricate system of shallow bays and bayous lying southwest of Indian Mound Bay. The bottom is almost everywhere composed of a very soft, deep mud, and the density of the water is low. The oysters are usually long, narrow, clustered, and rather poor in condition and flavor. The shells are covered with great clusters of large mussels and some barnacles, the growth of the former being more luxuriant than at any other place in the Parish of St. Bernard. Immediately south of Dutchman Pass there is a rather dense bed of oysters lying in a bight behind a small island. Upon the denser parts of this bed the oysters are rather small and are in clusters, but near the edges, in the deeper water, there is a scattering growth of single oysters of excellent shape and flavor and very fat. A limited amount of young growth is found upon these single oysters, but the denser growth near shore is well covered with spat. The bottom in the vicinity of this bed is composed of hard mud.

Mississippi Sound.—There are probably beds of oysters scattered here and there on the shoals throughout such parts of Mississippi Sound as fall within the limits of St. Bernard Parish, but with the exception of those near the entrance to Lake Borgne and in the vicinity of Isle á Pitre they are rarely or never worked by the oystermen and were not investigated by the *Fish Hawk*. Scattered oysters cover the whole stretch between Lake Borgne Light and St. Joseph Island, but as they lie within the limits of the State of Mississippi they are not represented on the chart. In the deep waters lying between Lake Borgne Light and Half-moon Island many small beds of oysters are found in depths of from 7 to 25 feet, most of them being in less than 15 feet. These beds, being small and numerous, could not be definitely located without the consumption of more time than was at our disposal, and they are therefore indicated only in the most general way on the accompanying chart. Upon most of these the growth was a scattering one, but there was one bed lying in 8 to 10 feet of water which was quite dense. There is another dense bed lying on the northeast side of Half-moon Island, close inshore and in a depth of from 3 to 7 feet, where all of the oysters were small, apparently the result of last year's spatting, and in dense clusters. They will probably be fit for use in the canneries next season, but unless broken up and transplanted they will never be suitable for the "shell trade." This is evidently an old bed recently rejuvenated.

About 2 miles east of Half-moon Island lies a bed known as Grand Bank. It is in from 9 to 13 feet of water and extends about north and south for about 1¼ miles, with an average width of about ⅜ mile. The oysters here are in bunches, rather scattering, and of small size. It is stated that this bed was formerly very productive, but that it has been ruined by steam-dredges.

On the south side of Half-moon Island there is a scattering growth beginning near shore and extending out for a distance of about a mile. The oysters here are not uniformly distributed, but occur in patches usually of small size, although there is one large bed, triangular in shape and measuring about ½ mile in base and altitude.

South of Grassy Island is a circular patch of scattering growth about ½ mile in diameter. About ¾ mile southwest of the same island lies a smaller but somewhat denser bed.

A dense bed, circular in shape and about ½ mile in diameter, occurs southwest of Round Island, in about 6½ to 7 feet of water, and from the southwest side of the island a very scattering growth extends for about ½ mile, where it merges with a well-defined bed.

Off the north point of Le Petit Pass Island is a bed of scattering oysters, and on the east side there is another bed, a portion of which is covered by a dense growth. About midway between Le Petit Pass and Nine-mile Bayou there lies a crescentic bed, beginning ¾ mile from shore and stretching in a general northeast direction for about 1½ miles. Upon all of these beds the oysters are poor in size, shape, and flavor, being in clusters of the raccoon type, and fit only for use in the canneries. At the time that these beds were visited there were a number of vessels working upon them with tongs, and between Half-moon Island and Lake Borgne a steam-dredge was engaged in scraping the bottom. The oystermen claim that the dredges have caused much harm in this vicinity. The water here is always comparatively fresh, owing to the discharge from the Pearl River and Lake Pontchartrain, and apparently the oysters are sometimes killed by the low salinity, an explanation which would account for the existence of beds composed entirely of young growth on old, dead shells. In the latter part of February the average density of the water north of Half-moon Island was 1.0012, and south of the island it was 1.0028. This was without doubt lower than normal, as the readings were taken immediately after a period of heavy rainfall. It is doubtful if the oysters could withstand such a low density for any considerable period, and they probably do so for a limited time only by tightly closing their shells against the admission of the objectionably fresh water. It was noticed that certain marine animals, notably species of worms, were either dead or dying on the beds north of Half-moon Island.

There is a small bed of oysters just at the mouth of Turkey Bayou, and a considerably larger bed, now almost exhausted, lies about ½ mile offshore, midway between Drum Bayou and Grand Pass.

Lying south and southwest of South Shell Bank and stretching as far as the north of Grand Pass there is an extensive oyster-bed known as Cabbage Reef. It receives its name from the abundance of the seaweed ulva, known to fishermen as "sea cabbage." The growth on this bed is very scattering and it appears to be rarely worked by the oystermen, although formerly it was an important oyster-ground. It is stated that the oysters here were nearly exterminated by the conchs, and that most of those not so destroyed were covered with mud and sand during the great storm of 1893. Practically continuous with this bed there is a moderately dense growth skirting the north shore of Isle à Pitre and extending more or less into the bayous, as far as the edge of the deep water lying to the westward of Deep-water Point. Most of these oysters, both along shore and on Cabbage Reef, are of moderate size and in clusters of from 5 to 15. There are but few mussels or barnacles, but there was in February a moderate growth of seaweed, which is said to become more extensive later in the season. Young growth and spat are abundant. East of Deep-water Point there are no oysters excepting a scattering growth in a salt pond, now closed but formerly an open lagoon.

Chandeleur Sound.—There are now, according to the testimony of the fishermen, very few oysters to be found in Chandeleur Sound, although there were formerly beds of considerable extent in several localities. No detailed examination of this region was made, although the shores were explored in a few places.

There appear to be very few, if any, oysters on the outer shore between Isle à Pitre and Door Point, but there were formerly some more or less extensive beds between Door Point and Pelican Point, as well as in the neighborhood of Brush Island and outside of Deep Pass. In Live Oak and California bays, around the shores of Martin, Sam Holmes, and Mitchell Islands, there are beds of old shells where there were formerly productive oyster-reefs frequented by oystermen. The general opinion of oystermen is that these beds have been exterminated by the conchs.

THE NATURAL OYSTER-BEDS OF PLAQUEMINES PARISH.

East of the Mississippi the oyster-beds of Plaquemines Parish stretch from Mozambique Point to Bird Island Sound. Formerly the oysters in this region, especially near Mozambique Point, were large and rather desirable in quality, but in 1897 most of them were killed by the Bohemia crevasse, and at the time that the beds were examined it was found that Quarantine and California bays contained practically no adult oysters, although there were a number of dense reefs of young growth, many of which had their crests exposed at low water. The fishermen state that the beds are now numerically far richer than before the crevasse—a statement which an examination shows to be extremely

probable. Nearly every old shell on these reefs bore young, and many of them were completely covered by oysters from 1 to 3 inches long.

In their present crowded state it is not likely that these will develop into good oysters, either as regards shape or condition, for as they increase in size many of them will be killed by the growth and crowding of their fellows, and the remainder will show in their poorness and irregularity the bad effects of their severe struggle for existence.

It would be of great advantage to have some of the superfluous oysters removed. If half of those now on the beds were taken up, the clusters broken, and the single oysters planted on suitable bottom, there would result not only an improvement in those planted, but also in those left upon the beds. This is one of the instances where it would be advisable to depart from a general policy of prohibition of the removal of small oysters from the natural reefs. Some of these oysters were taken to the planting-grounds west of the river while the canal was still open, subsequently to the crevasse; but that avenue is now cut off, and the voyage around the Delta is so long as to make it more advantageous for the planters to go to Timbalier for their seed. It is not at all unlikely, however, that planting could be carried on with some advantage on the east side of the river, where it is now extremely limited in extent.

South of Bird Island the heavy discharge of fresh water from Cubits Gap so reduces the normal salinity as to prevent the growth of oysters, and in Garden Island Bay, where natural reefs formerly existed, the oysters were exterminated by the Pass à Loutre crevasse. The only natural reefs now existing in the vicinity of the Delta are a small one in East Bay and another in West Bay, near Southwest Pass.

West of the Mississippi River the natural reefs of Plaquemines Parish are limited in extent and of but little importance as compared with the planting interests. There are a few oysters of volunteer growth in August Bayou and in Cyprian Bay. In Chi Charas Bay there are said to be several reefs, which give employment for a term each season to from 30 to 40 boats. These beds are overfished, and are said to have decreased greatly during recent years, although it is probable that they were never very extensive.

In Bayou Cook the natural beds were long ago exhausted, and in Bay Adam, where there were originally a number of reefs, practically no oysters are now taken from them, although occasionally some are caught. In Bastian Bay there are still some natural reefs from which oysters are taken each season, but these also are said to be much less productive than formerly, and doubtless will before long become extinct.

In that part of Barataria Bay lying within the limits of Plaquemines Parish there are now no productive natural reefs, and even the remnants of those previously existing are fast disappearing through the destruction and dissolution of the dead shells.

THE NATURAL OYSTER-BEDS OF JEFFERSON PARISH.

This parish includes within its limits the major part of Barataria Bay, formerly a productive oyster region, but now exhausted. Several days were spent in examining these waters, but with one exception not a reef was found which was not extinct from an economic point of view and fast approaching that condition biologically. The exception noted is in Bayou des Islettes, where there are a few fine large oysters in a hole 25 feet deep, where they can not be reached by the tongs of the oystermen. The reefs are all in the southern half of the bay, the northern half having never produced oysters within the recollection of the inhabitants, probably owing to its low normal salinity. A large area of marsh and swamp land drains into this bay and as its mouth is almost closed by islands the influence of salt water from the Gulf of Mexico is not sufficient to counteract the influx of fresh water in the north.

That this region was at one time an important one is evidenced by the number of extinct reefs which are to be found, as well as by the testimony of the inhabitants. None of these beds appear to have been very extensive, and in this feature they resemble, in general, those in other parts of the State, but their number makes the total area not inconsiderable. It is not necessary to indicate the location of these reefs other than to say that they are scattered through Caminada Bay, Bay Coquette, Tambour Bay, Bay Joyeuse, Bay des Islettes, Champagne Bay, along the shores and islands of Grand Lake, which is the main body of Barataria Bay, and in Cat Bay, or Bay Devise, as it is called locally. All of these reefs are of the same character. They are for the most part composed of dead oyster-shells, with occasionally a large single oyster of fine flavor and shape. There is practically no young growth, for which there appear two probable reasons—the dearth of adult individuals to furnish the spawn and the absence of suitable cultch for the attachment of the young.

The dead shells are worm-eaten and corroded by the boring-sponge and the clam-like Martesias. They are fast disappearing and passing into solution, and with their disappearance there will pass practically all that distinguishes the reefs from the surrounding bottom, thus making more and more remote the possibility of the recuperation of Barataria Bay as a natural oyster-ground. It took nature many years to erect these reefs upon the soft and muddy bottoms of the bay, but a few years suffice for their destruction. Already, in Champagne Bay and elsewhere, the shells upon the surface of the mud have disappeared, and the location of the old reef is marked only by the shells which have sunk into the ooze or have been buried beneath the sediment deposited by the water. In the section of the report dealing with matters relating to oyster-planting there is pointed out a method of utilizing these extinct reefs.

The cause of the destruction of these reefs appears to have been overfishing in some form or other, more probably that species of improvi-

dence which results from lax enforcement of the culling laws. There is no reason for believing that the beds were exterminated by oyster enemies, although there is no doubt they did some harm, and no crevasse has occurred during a period which would allow it to be offered in explanation of the facts observed. Crevasses, and enemies, with few exceptions, leave the shells upon the beds to serve as cultch and assist nature in her efforts at recuperation; but the overzealous oysterman, raking seed from the natural beds, sometimes leaves not even the shells. It is stated that for six or seven years oystering was here carried on in a destructive way by men engaged in planting on other parts of the coast. It is claimed that not only the small oysters but even the shells were carried off, and the present condition of the beds lends color to the belief that the statement is true, at least in part.

What has already occurred here is now taking place elsewhere, and it behooves those interested in the oyster business of the State to correct a condition which will before long result in irremediable damage.

THE NATURAL OYSTER-BEDS OF LA FOURCHE PARISH.

The oyster regions of La Fourche include portions of Caminada and Timbalier bays. The few oyster-beds at one time existing in the former are now extinct and in the same condition as those in Jefferson Parish. The two bays are connected by a canal, which furnishes the main avenue of communication between Timbalier and the planting-grounds of Plaquemines and the markets of New Orleans.

At its western end the canal opens into Little Lake, in which there is an extinct reef of small size, now utilized as a bedding-ground when the oysters in Timbalier Bay are too salt. It is not improbable that this reef was destroyed by the fresh water discharged into the lake by the canal leading from Bayou La Fourche, the density here being but 1.0044.

The most important oyster region in the parish is on the northeast side of Timbalier Bay, in the vicinity of Jacks Camp, Camp Malnommé, and Bayou Landry. At each of these places, but especially at the first, there are considerable villages composed of the rude camps of the oystermen built upon piles on the sea marsh. In the immediate neighborhood of the camps the oystermen have their bedding-grounds, upon which the oysters are stored until the cargo of the boat has been completed.

There are reefs all over this part of the bay, the oysters being of moderate size and good flavor. The density is about 1.0160. Upon all of these reefs there is a good growth of young oysters, from 1 to 3 inches long, about 50 per cent of the old oysters and dead shells having young growth attached. A hurried examination of these beds indicates that they are in a fairly satisfactory condition and not in danger of extermination unless through neglect of proper culling. There appears to be no doubt that their productiveness has decreased during the past four or five years, and from the estimates of a number of the oystermen

it seems that the average daily catch per man has fallen off at least 60 per cent, and probably more. One important factor in producing this diminution is that large numbers of young oysters are taken from the natural reefs and planted in other parts of the State. During certain months of the year this business is quite extensive, and the drain on the natural reefs is very considerable.

It is immaterial for what purpose these young oysters are taken—whether for transplanting to distant beds or to be thrown upon the shell pile, the effect upon the reef is the same. In one case, of course, they are wasted, and in the other they serve a useful purpose, but in either case the natural beds are rendered less productive and placed one stage nearer extinction. It can be readily seen that if this removal of the young continues, whatever may be the reason or pretext, the time must soon arrive when there will be neither young nor old, neither marketable oysters nor seed, upon the natural reefs. It was in all probability some such cause as this which led to the extinction of the reefs in Barataria Bay. There are said to be 200 boats licensed to fish on the natural reefs of La Fourche Parish, but many of them have lately moved into Terrebonne Parish on account of the partial depletion of the beds near Jack's Camp. There are no oysters excepting raccoons south of Grand Point, although there are some young oysters of good shape in Champagne Bay just eastward of the mouth of Bayou La Fourche.

THE NATURAL OYSTER-BEDS OF TERREBONNE PARISH.

Terrebonne Parish contains the most important oyster-grounds of the State, and there are 600 boats of all kinds licensed to fish within its borders. The oyster-producing waters extend from the eastern part of Timbalier Bay almost to Atchafalaya Bay, where the influx of fresh water places a limit upon the growth of the oyster-beds.

In the northern part of Timbalier Bay there is a newly discovered oyster-bed lying in a small bay. These oysters are of rather inferior shape, being somewhat of the raccoon type, as is often seen on beds which have not been worked. There were 9 or 10 boats fishing here. In Pass Felicity there are a number of beds of oysters somewhat like those found in the vicinity of Jack's Camp. In the southern part of Lake Felicity there are beds of long, thin-shelled oysters growing on the soft mud along the shores. The young growth here is but moderate in quantity. It is stated that the oyster-planters to the eastward carry away shells and oysters, large and small, from these waters. Along the northwest shore of Lake Felicity there is a reef, upon which the oysters are in small clusters, of good size and shape, and with an abundance of young growth. In this lake mussels are often quite troublesome, overgrowing and crowding the oysters, and making it difficult to cull them. The density is 1.0100.

There are oysters on the northwest shore of Lake Barré, especially in the places known to the oystermen as Mud Bayou, Hatchet Bayou

(Bayou la Hache), and Muddy Bayou. There are a good many reefs, but very few oysters, in Bay Jocko, which lies between Timbalier Bay, Terrebonne Bay, and Lake Barré. No very definite information in regard to this region was obtained. The northern part of Terrebonne Bay was not visited, but the following general information concerning it was derived from reliable sources. Oyster-reefs are scattered over the northern two-thirds of the bay, both along the shore and out in the middle, but there are not many as far south as Point-of-Marsh. The water varies from 2 feet to 22 feet in depth over the oyster-beds, but the latter depth is unusual. The water is said to be fresher than in Timbalier Bay, a statement which seems probable in view of the discharge of Bayou Terrebonne and Little Caillou Bayou into the bay, and which is confirmed by the readings taken in corresponding parts of the two bodies of water. In the western part of Timbalier Bay the density was 1.0179, while at Point-of-Marsh, the corresponding part of Terrebonne Bay, it was but 1.0128.

It is stated that fifteen years ago there were no oysters above Bayou Lagraisse, nor in some of the small bayous of Lake Barré, and their presence there now is supposed to be owing to changes in the drainage due to the cutting of timber along the bayous and the washing of the islands. The topographical changes in the region between Timbalier and Terrebonne bays are quite extensive and rapid, and islands were observed there in all stages of destruction, some of them cut into pieces, others barely showing above the water, and still others whose former positions were marked merely by shoals or by dead brush projecting above the surface. It appears probable that these changes might have produced considerable alteration in the hydrographic characters, and thus have changed the adaptability of the waters for oysters.

Some of the oysters from this bay were examined and found to be of fair size and shape and good quality and condition. In general they somewhat resemble those from Jack's Camp, in Timbalier Bay.

The drumfish is the principal enemy of the oyster in Terrebonne Bay, the waters being too fresh to be very suitable for the snail (*Purpura*). Mussels are sometimes troublesome in the fresher waters.

The testimony in regard to the relative abundance now and in the past is contradictory, but it seems probable that while there may have been an extension of the area over which the oyster is found, there has been at the same time a diminution in numbers upon the beds which have been worked. Young oysters for planting purposes are now taken extensively from Terrebonne Bay to Bayou Cook and vicinity, and the beds in Terrebonne Bay are being worked more extensively than formerly, owing to the partial depletion of the beds in Timbalier. In the vicinity of Point-of-Marsh are some extinct oyster-reefs with a few dead shells, sponges, and other forms commonly abounding in such places.

In Pelican Lake, lying immediately west of Terrebonne Bay, there are considerable quantities of raccoon oysters on the flats. These are not fit for the markets, but could be utilized with profit in planting. Some of the natural reefs here appear to be approaching exhaustion,

although there still remain on them some rather good oysters of elongated form. The old shells are much sponge-eaten, and badly suited to catch young spat.

In Wilson Bay there were formerly several very good beds upon which the oysters fattened early in the season, but these have now been exhausted by overfishing. A few men fished here early during the past season, but they soon found the work unprofitable and abandoned the grounds for more favorable fields.

In Pass des Isles there are a few reefs of good oysters, and in the small bayous leading off from it raccoon oysters abound. The reefs in Lake Chien, which were productive eight or ten years ago, are now practically exhausted, and many of the men who fished there have gone to Sister Lake. Here also there is no doubt that the extinction of the beds was due to overfishing, coupled, perhaps, with laxness in culling, especially on the part of those engaged in planting. There are still many raccoon oysters in the bayous opening into the lake, and these are now used as seed by the planters.

In Grand Bayou de Large there are about twenty camps between the Gulf and Sister Lake (Lake Caillou, in part), and there are oysters all along this stretch, in water varying in depth from 8 to 22 feet. Several men are engaged in planting. This bayou appears to be the Bayou Grand Caillou of the published charts and maps, but, if so, it is very incorrectly laid down. It is difficult to identify many of the bodies of water between Timbalier Bay and Oyster Bayou or Four League Bayou, as the mapping of this region was either extremely faulty in the first instance or else the topography has undergone most remarkable changes. On some maps lakes are shown where none exist; on all of them important bodies of water are not shown at all, and many of those indicated are incorrect, both in position and topography.

Lake Barré, which is about 8 miles long and 3 or 4 miles broad, is not shown at all on some of the maps published under both United States and State authority; there is no lake east of Lake Felicity; Lake Chien (southeast of Sister Lake) is not shown on any map which I have seen; Sister Lake (Lake Caillou) is entirely wrong in both outline and position, and King Lake, which is practically a bay of Sister Lake, is, with its connections to the westward, not shown at all. It will therefore be impossible to indicate very definitely the positions of the places mentioned, and they will be called by the names used by the oystermen rather than those used on the maps.

In Sister Lake there are oyster-reefs at intervals along the shores, in addition to those in the center of the lake, the oysters being generally of good quality, the best coming from a reef near the discharge of the lake into Bayou de Large. When first discovered they were rather inferior in shape and condition, but, as is usually the case, the oysters have improved in both respects, owing to the breaking up of the clusters and the thinning out of the dense growth. It is stated that a man can take from 4 to 8 barrels of oysters per day in these waters,

and there appear to be no immediate grounds for apprehension of failure. Several of the oyster-reefs in Sister Lake are sometimes overgrown with mussels to an extent that renders tonging upon them unprofitable. The density is about 1.0120.

Bay Voisin leads from the southeast corner of Sister Lake to King Lake, an L-shaped body of water, with one limb running east and west and the other approximately north and south. There is one bed of raccoon oysters in King Lake, and there are also some very fine oysters there and in Bay Voisin, but they are getting somewhat less abundant than they have been. Some of the oystermen predict a rapid depletion of the beds, owing to the attacks of snails, which are said to be becoming more common than formerly.

In Lake Washa there are numerous reefs of rather inferior "coony" oysters, covered with barnacles and bearing evidence of having formerly borne large numbers of mussels, of which only the byssi now remain. These reefs have not been extensively worked heretofore, but during the present spring (1898) a number of boats were fishing for Morgan City canneries, and several of the men engaged indicated their intention of getting seed from this lake for the purpose of planting in Jack Stout Bay and Bayou. If this be done and the young oysters be taken promiscuously in the usual manner, we may expect the usual results. The density here is about 1.0092.

In Banana Bayou, which is that part of Bayou de Large of the maps lying between Sister Lake and Lake Washa, there are young oysters growing over practically the entire bottom, and they are frequently found attached to branches of trees and brush along the banks. This bayou is said to have derived its name from the fact that the oysters found here when the bed was first worked were elongate and in clusters like bananas. The lower end of Bayou de Large, together with the branch which discharges King Lake, is known to the oystermen as Taylor Bayou. It contains some oyster-beds, but none of importance.

Big and Little Bays Genope (or Genoble?) lie immediately to the westward of Bayou Taylor and have an independent communication with the sea. They are both very shallow and have a narrow channel running through them. Here are found dense reefs of raccoon oysters, exposed at low water, when they are gathered into piles to be loaded on the boats when the tide rises. These raccoon oysters are used principally for planting in Bayou Jack Stout, Bayou Provençal, and Indian Bay, all of which lie on the east side of Bayou Taylor.

In Oyster Bayou there are a number of natural reefs of raccoon oysters, both along the banks and in the middle of the bayou. The number of good round oysters is small.

There are a few beds of inferior oysters near the southern end of Four League Bay and near the mouth of Blue Hammock Bayou. Last year (1897) there was a set of spat in Blue Hammock and the young ones are now being secured for planting purposes. Oysters have existed here before, but were killed off by fresh water.

West of Atchafalaya Bay the oyster-beds are few and unimportant. The set of the currents of fresh water discharged from the Atchafalaya is westward and their volume is such that the water of Atchafalaya Bay, East Côte Blanche Bay, West Côte Blanche Bay, and some parts of Vermilion Bay is too fresh to support oyster life. In some parts of Vermilion Bay and Marsh Island there are a few inferior oysters and it is reported that there is a bed of considerable size in the open waters of the Gulf off Southwest Pass. There are said to be a few insignificant beds in Calcasieu Pass and perhaps some at other inlets west of Vermilion Bay, but in general the character of the coast line is not such as to favor the growth of oysters, as the sounds, bays, and bayous which are the favored home of the oysters are lacking.

NATURAL OYSTER-BEDS—SUMMARY.

There are no oyster-beds in Lake Borgne, owing to the low salinity of the water. Beginning at the islands at the western end of Mississippi Sound, there are scattered beds as far as Isle à Pitre. There are now few, if any, oysters in Chandeleur Sound, although they formerly existed there. The cause of their extermination was not fully determined. In nearly all of the interior bays and bayous intimately connected with Mississippi and Chandeleur sounds there are more or less extensive beds, most of which have not yet been worked to their full capacity, and some of which contain virgin beds of great productiveness, although the oysters are usually rather inferior in quality. In several places the productiveness of the beds has been considerably reduced and in others, *e. g.*, Three-mile Bay, the present supply is entirely dependent upon the care with which the oysters are culled. There is no immediate prospect of the extermination of these beds, owing to their great extent, the chief danger being that the concentration of effort upon a comparatively limited area and the taking away of large numbers of young oysters to the canneries may in time prove destructive. The safeguard is to enforce proper culling laws.

In Plaquemines Parish, east of the Mississippi, there are extensive beds of young oysters, practically untouched by the hand of man, stretching from Mozambique Point to Bird Island Sound. From Bird Island Sound around the Delta to Barataria Bay there are no natural reefs of importance, those formerly existing there having become nearly or entirely extinct, some by reason of overfishing and breach of the culling law and others as the result of crevasses.

In Barataria Bay and its contiguous waters the reefs are commercially extinct and apparently beyond hope of redemption by natural means, principally, if not entirely, as a result of destructive methods of fishing. These reefs have probably no future value except for planting, and unless soon utilized will eventually become of no greater value than the surrounding bottom.

In Timbalier Bay and Lake Felicity the beds are still quite productive, but are already showing signs of approaching depletion to an

extent that has induced some of the oystermen to resort to other waters. In Terrebonne Bay there is probably as yet no great decrease, but between Terrebonne Bay and Atchafalaya Bay many of the more limited beds have been exterminated or reduced to a condition where it is unprofitable to work them; other places are still productive, but not to the same extent as formerly.

OYSTER-PLANTING IN ST. BERNARD PARISH.

Notwithstanding the extent of the oyster business in the parish of St. Bernard, no oyster-planting is carried on there, nor, apparently, has any effort been made in that direction. The oystermen working on the natural reefs habitually set apart certain circumscribed areas of hard bottom upon which they bed their oysters until they have caught enough to make a cargo. Toward the end of the season, when many of the beds become more or less depleted by the drain which the steady prosecution of the industry entails, it frequently requires as long as fifteen days for the crew of a vessel to catch a full load. Under such circumstances oysters taken during the earlier part of the trip would spoil before the boat was ready to sail, and to avoid this it is customary to "bed" the culled oysters every few days in a place whence they can be conveniently removed when the cargo is completed. The oysters are bedded very thickly on these grounds—often, it is said, to a depth of a foot—so as to allow of their recovery with a minimum expenditure of labor when the load is completed, and were this done on soft bottom the oysters beneath would be driven into the mud and suffocated; and for this reason the beds are almost invariably placed upon the reefs, which often afford the only hard bottom to be had. The beds are small—averaging, perhaps, about 50 feet square—and are usually marked and sometimes inclosed by stakes to keep off the drumfish, which often prove destructive. For the same purpose many of the beds are surrounded with old seines, which prove effectual barriers, or by lines with pieces of rag attached, which scare the fish away.

A few of the oystermen fishing in the salter water at the eastern end of the parish sometimes set down their catch in the fresher water near Three-mile Bayou to "fatten," as they say, but in reality to undergo a process of bloating, due to the osmotic interchange of fluids within and without the tissues. The reverse process has been occasionally practiced at times when the discharge of fresh water through Lake Pontchartrain and the Pearl River has been of sufficient volume to reduce the salinity over the oyster-beds and render the oysters too insipid for market. By transplanting the oysters for a short period to the denser water of Chandeleur Sound it was found possible to improve the flavor to an extent which rendered the oysters salable. Certain of the oystermen residing on the shores of Mississippi Sound sometimes find no immediate market for their catch, and by bedding the oysters temporarily near their residences where they can not be stolen, are able to wait until the market improves and better prices prevail.

The nearest approach to planting as it is practiced elsewhere in the State—at Bayou Cook, for instance—is done by a man who has been bringing oysters from Grand Pass (Oyster Bay) and bedding them near Pirate Point for a few days. The culls and shells are thrown down on the bottom adjoining, and this has resulted in the formation of beds which he reserves for his private use.

Such is the present extent of planting, if it may be so called, in the parish of St. Bernard. A very large part of the bottom in this region is probably unsuitable in its natural state for oyster-culture, but were the profits sufficient to warrant it there is no doubt that much of it could be improved in a manner to make it available, as will be pointed out hereafter.

There is some bottom, not on the natural reefs, which is suitable in its natural or unimproved condition, but the patches of hard bottom are usually small and scattered, and, in the absence of anything more than a mere reconnaissance, such as the time at the disposal of the party made possible, the exact locations of these places can not be indicated. There are a number of such places in East Karako Bay, however, where both the bottom and density are favorable, and other localities are indicated in a general way on the chart.

In False-mouth Bay the bottom consists of a firm clay mud similar to the soil of the surrounding marshes and apparently well adapted to oyster-culture. There are no natural-bed oysters in this region excepting a few near Shell Signal and around some of the islands at the southern end of Nine-mile Bayou.

It is stated by the oystermen that but few oysters have ever existed here, a condition brought about apparently by the absence of suitable places of attachment, as practically no shells or other hard bodies were found on the bottom. It seems probable that, by sowing shells with some brood oysters to furnish spat, successful culture might be here carried on, the only drawback being the low salinity of the water, which, at the time of our visit, February 12 and 14, 1898, ranged between 1.00514 and 1.00664, and rendered the oysters insipid, notwithstanding their fatness. This density was probably nearly normal for the season, but, as elsewhere in the region, it is subject to great fluctuation according to the rainfall and the prevailing winds, and in summer, between April 1 and September 15, it is considerably higher than at the time our observations were made.

OYSTER-PLANTING IN PLAQUEMINES PARISH.

East side of river.—In that portion of the Parish of Plaquemines east of the Mississippi River, oyster-culture is not extensively carried on, but in the vicinity of Quarantine Bay, in Bayou Tortillon, and in the northern part of Bird Island Sound near the Salt Works Canal, there are a few men engaged in the industry. Oysters are taken from the natural beds, separated from the clusters, and replanted on private beds. The principal advantage which this region possesses appears to

lie in the fact that the oysters here become fat earlier than those on the west side of the river, and they are, therefore, more in demand in the markets of New Orleans upon the opening of the season in September. In 1897 the oysters at Salt Works were found to be through spawning and quite fat during the last week of August, while many of those examined at Bayou Cook the day before were still spawning and inferior as to condition.

The oysters now (March, 1898) on the private beds in Quarantine Bay were obtained from the vicinity of Mozambique Point and Rivière aux Chênes, and were planted during the summer of 1897. During the spring of that year all of the private and natural beds in California Bay and Quarantine Bay were destroyed by the fresh water discharged from the Mississippi River by the crevasses occurring at Bohemia and at the several canals opening into the bays under discussion.

The principal enemy with which the planters here have to contend is the drumfish, which has become so troublesome as to compel the erection of close and rather expensive stockades for the protection of the bedding-grounds. Formerly these protections were built with rails about 6 inches apart, but they are now constructed of pickets close together, entering the mud at the bottom and nailed to stringpieces at the top.

Whale Bay and Grand Pass.—Oyster-planting began here about 1885, the pioneer and most successful operator being Louis Espongar, who in that year began to transplant oysters from the natural beds in Garden Island Bay, between South Pass and Southeast Pass. He appears to have been the first man to appreciate the importance of planting cultch to catch the spat, and carefully collected oyster shells and other suitable materials for that purpose, even, it is stated, stipulating the return of shells when he sold his oysters unopened to the residents of Port Eads.

After some years others began to establish private beds in Whale Bay, until 1892 depending for their seed oysters upon the natural beds existing in Garden Island Bay. In 1892, however, the water from the Mississippi River broke into the head of Garden Island Bay at what is known as the Pass à Loutre crevasse, flooding the bay with fresh water and killing the oysters. This gap has until the present time resisted all attempts at its closure, and the oysters have never reestablished themselves. Deprived thus of the only extensive near-by source from which to obtain their seed oysters, the planters had to choose between establishing spatting-grounds and depending upon the young oysters attaching to the cultch, or making the long and sometimes stormy trip to Timbalier or the coast north of Bird Island Sound, the nearest places in which seed oysters could be obtained in sufficient quantities for their purpose.

It was found that the destruction of the oysters in Garden Island Bay had left large quantities of shells available for use as cultch, and the experience of Mr. Espongar dictated the use of these as the easiest

and most economical way out of the difficulty, and large quantities were therefore carried to Whale Cove and laid down on the spatting-beds. In this way was established the methods of oyster-culture now in vogue.

Since the preparation of the Coast Survey charts of this region the topography has greatly changed, the marshes formerly existing in the northern and western part of the bay being now cut up into numerous small islands and channels. The dam built across the head of Grand Bayou has resulted in the complete closure of the mouth of the bayou, which is now in its southern half, separated from Whale Bay merely by a chain of narrow islands with passes between. It is upon these islands, both in the bay and along the shores of Grand Bayou, that most of the planting is done.

The area of bottom naturally available for oyster-culture appears to be extremely limited, being confined to narrow strips along shore and varying in width in different localities, in Grand Bayou extending from shore to a distance of from 25 to 50 feet. Outside of this zone the bottom is generally soft—often extremely so—and it is never utilized for planting. Under the laws of the State each planter is entitled to hold 10 acres in his own right, but for the reasons stated it usually happens that a large proportion of his holding is useless for his purposes. There are about six men planting here, and their holdings probably amount to between 100 and 125 acres, some of them occupying bottom in the names of friends or members of their families. Most of them appear to be anxious to increase their acreage, but they claim that the entire available area is now occupied. Notwithstanding this demand for extension, no effort has been made to improve the bottom in such a manner as to render it suitable for planting. It seems probable that this might be done by covering the mud with a thin layer of sand, such as can be readily obtained at the mouth of Grand Bayou and at other places in the vicinity. As is well known, this method has been employed with great success elsewhere, and a large amount of valuable oyster-land in Connecticut was useless until similar measures were adopted. The problem is an economic one and hinges upon the question whether or not the price obtained for oysters from this region is sufficient to warrant the expenditure. As the sand costs nothing, the only expense would be for labor and transportation, neither of which would be a large item under the conditions here prevailing.

At the present time all shells and other available materials—tin cans, stones, bones, etc.—are strewn along the shores of the marsh below the level of high water and out from the shores to the depth of a foot or 18 inches. Much of this material is thrown among the grasses and sedges, where it is never covered by more than a few inches of water, even at high tide. It is stated, and undoubtedly upon good grounds, that in this extremely shoal water the young oysters are less susceptible to the attacks of enemies, and it is also claimed that they grow more rapidly than when they are in deeper water.

In shoal water, and especially when they are in clusters, the oysters grow in poor shapes; and for this reason the planter, as soon as the oysters are of sufficient size, usually at the end of the first year, breaks up the clusters into single oysters, which are then planted in the deeper water. They reach a marketable size—from 5 to 6 inches—in from 2 to 2½ years from the time of planting the shells, and are very fat and of remarkably fine flavor. It is estimated that about 100 bank barrels, or 300 bushels, of oysters can be produced annually from each acre of bottom; that is to say, the usual crop is 300 barrels every three years.

Cultch and seed oysters being greatly in demand, the culling is done with extreme care, all shells and young oysters being carefully saved and returned to the natural bed.

It is rather surprising to find oysters of such fine quality in such close proximity to the mouth of the Mississippi River, where it might be supposed that the water would be entirely too fresh for their welfare. The density fluctuates with the direction of the winds, but is usually conditioned by the stage of water in the river, being lowest during the freshets of winter and spring and highest during the low water of the summer months. March 4, 1898, when the river was at a moderate level after a period of high water, the density on the oyster-beds was between 1.0109 and 1.0116, corrected to a temperature of 15° C., or 60° F. The temperature was between 11.5° C. and 13° C., or 52.6° and 55.6° of the Fahrenheit scale, a temperature lower by several degrees than was found elsewhere upon the oyster-beds at that time, a condition probably due to the influence of the cold water from the Mississippi River.

The principal enemies of the planted oyster in this vicinity are the conch (*Purpura*), the drumfish, and the stone-cracker, a species of ray. The conch is very troublesome at times and the drumfish causes damage during the summer months, but is much less destructive than at Bayou Cook. The stone-cracker appears here but occasionally, but its visits are very disastrous in proportion to its numbers. It seems to be unknown to the oystermen elsewhere.

The oystermen at Balize have planted oysters in the small bay immediately west of the mouth of Southeast Pass. This place was not visited, but the conditions doubtless resemble those obtaining in Whale Bay.

Bayou Cook and vicinity.—The most extensive planting-grounds in Louisiana are the series of lakes, bays, and bayous lying between Bay Jaque and Bastian Bay, a large part of the best oysters found in the markets of New Orleans coming from this region. It is estimated that there are upward of 500 men engaged in the several branches of the business in this region.

In Bay Pompadour, the farthest inland of the chain of lakes connected with Bay Jaque, there are neither planted oysters nor natural reefs, owing principally to the low salinity of the water. There are a few natural-bed oysters, but no planted ones in August Bayou, which

leads from Bay Pompadour to Cyprien Bay, but in Cyprien Bay itself, and in Schofield Bay and Skipjack Bay, which open into it from the south and southwest, there are a number of planted beds on which are raised oysters of excellent quality. There are apparently no planted beds in Chi Charas Bay, but in Bayou Coquette, Bay Coquette, and Bay Jaque the industry is of some importance, although of but comparatively recent growth.

Both young oysters and shells are planted, the former being at present the more important branch of the work. Most of the seed oysters now on the beds were obtained in the vicinity of Quarantine Bay during the period when the open canals after the crevasse of 1897 permitted direct communication with the river. It is probable that hereafter the planters will use shells more extensively, rather than make the long journey to Timbalier or Terrebonne for seed, these being now the nearest natural beds having direct communication by water.

It is estimated that about 300 bank barrels (900 bushels) of seed oysters are planted per acre of bottom, and under good conditions these are said to increase about 100 per cent in 1½ to 2 years. I was informed that in one instance, where 475 barrels had been planted on a certain piece of bottom, 480 barrels were taken up in the following year, and it was estimated that an equal quantity still remained.

The quantity of shells planted per acre could not be ascertained, owing to the practice of spreading them along the shores in the shoal water, as has been described in connection with the subject of planting at Port Eads. The bottom suitable for planting occurs in patches here and there, and there is apparently no large area of hard bottom not interspersed with soft mud.

The principal enemy of the oyster here is the drumfish, and the bedding-grounds are inclosed by rude rail fences to prevent its inroads.

In the markets of New Orleans the oysters from Bayou Cook have the best reputation of any grown in the State, and a large number of oysters grown elsewhere, many of them equal to the genuine, are put upon the markets and sold as Bayou Cooks.

Bayou Cook itself connects Bay Adam with Bastian Bay, and is about 3 miles long, broad at the two ends, but narrowing in the middle third of its length. The currents flowing through the bayou are moderately strong, it being the main channel for the ebb and flow of the tides affecting Bay Adam. It covers a bottom of considerable area, only a small portion of which is utilized in the methods of oyster-culture in vogue, although the oystermen state that all bottom naturally suited to the purpose is now in use. The bottom on the planting-grounds is usually, if not invariably, a hard mud, soft mud being avoided because the oysters sink in it and are lost, and the sand in the bayou being of a shifting character and liable to bury the beds during storms.

It is stated that in 1893 many hundreds of barrels of oysters were destroyed in this way, some of the oystermen prior to that time not appreciating the unstable character of the bottom. The hard mud, as

a rule, occurs in patches near the shores, the channel generally having a soft bottom, and in places being too deep for the tongs used in catching the oysters.

Although it is claimed that all of the suitable bottom in the bayou has been taken up and is now in use for planting, no attempt has been made to improve the soft bottom by covering it with a stratum capable of furnishing a support for the oysters. A few shells are planted along the shores in the manner practiced at Port Eads, but seed oysters from the natural beds are much more extensively used. The seed is brought principally from Timbalier and Terrebonne bays, which entails a voyage of about 50 miles at least, the payment of tolls in the canal, and the payment of a license fee in the parish in which the oysters are taken from the reefs. During the autumn of 1897 much sêed was brought from Quarantine Bay, but as soon as the breaks in the levee were closed this source of supply was cut off. The taking of seed oysters from the natural beds is a source of much complaint among the oystermen fishing for the markets, who claim that the boats engaged in the business pay but little attention to the requirements of the culling law and that large and small oysters alike are removed from the beds.

From 300 to 400 bank barrels (900 to 1,200 bushels) are planted on each acre of bottom, the oysters being spread as closely as possible without being in actual contact. They are planted in the usual manner, by being thrown broadcast from the boat with shovels or scoops. It is stated that oysters here reach a marketable size in about two years from the time at which they fix themselves to the shells, and that seed 3 inches long is ready for the market in one year from the time of planting.

The principal enemy of the oyster in Bayou Cook is the drumfish, which causes some damage during the summer, but is especially destructive during the months of September and October. Oysters which have been long bedded are not much damaged by the drumfish, but those which have been cleaned and laid down in preparation for market are especially liable to attack during the first few days. After that, probably either because they settle down slightly in the mud, or because they become coated with sediment and are therefore less conspicuous, they are not much molested. The oystermen all erect barriers around the bedding-grounds where the cleaned oysters are deposited.

The conch or snail is not very destructive in Bayou Cook, excepting near the entrance to Bastian Bay. Stone-crabs sometimes kill the oysters, especially those less than 3 inches long.

In Bay Adam the conditions are practically as in Bayou Cook, except that there is less current flowing over the beds and they are more exposed to storms. The planting-grounds are around the shores of the lake, especially in its southern half, and, as nearly everywhere on the coast of Louisiana, the area of naturally suitable bottom is comparatively small and much scattered. In Bayou Chute, which establishes

communication between Bastian Bay and the extreme southern part of Bay Adam, oyster-planting is also carried on to a considerable extent. In these places the drumfish is less troublesome than in Bayou Cook, but great damage is done to the beds by the conch or snail.

It is estimated that about 500 men are employed in oystering in the Bayou Cook region, practically all of whom are engaged in operations pertaining to planting and the transportation of the planted oysters to market. Most of these are alien-born, being principally natives of the Slavonic provinces of Austria, but there are also some native-born planters, usually creoles. In Cyprian Bay, Bay Coquette, and vicinity, most of the planters are creoles or other natives.

OYSTER-PLANTING IN JEFFERSON PARISH.

In Barataria Bay the oyster industry amounts to practically nothing, owing to the extermination of the natural beds and the almost complete neglect of oyster-culture. A few oysters are planted for home consumption near Grand Isle, and one or two men at that place plant a few for the markets, but the entire production for all purposes is very small. A few oysters from Timbalier are planted on a small bed in Bay Coquette, near the mouth of the canal, in La Fourche Parish. In Bay Devise, shown on the Coast Survey Charts as Cat Bay, one, or perhaps two, persons have planted oysters on what appears to have been formerly a natural reef, although it has not been productive for several years. In the few cases cited seed oysters are brought from Timbalier Bay, and it is stated that except at Grand Isle it is impossible to secure a set of oyster spat upon shell or upon cultch. The oystermen think that it is possible to do so at Grand Isle for some mysterious reason connected with the drainage of fresh water from the island, but it is probable that a set could be obtained anywhere in the southern half of Barataria Bay and its connected waters if there were but enough adult oysters to furnish the young. As there are practically no adult oysters, except those on the few planted beds mentioned, over the greater part of this region, it is useless to expect young oysters to grow. The belief of some of the oystermen that young oysters are generated spontaneously under certain peculiar conditions of admixture of fresh and salt water is a biological absurdity.

The general conditions for oyster-culture appear to be good, and it is quite probable, indeed almost a certainty, that self-perpetuating beds might be readily established by bringing adult oysters from the Timbalier or other natural beds and planting them upon suitable bottom in any part of Barataria Bay south of the mouth of Champaign Bay, and probably for some distance north of that point. In the upper parts of the main bay, which is locally known as Grand Lake, and in Hackberry Bay, Creole Bay, Bay Batiste, and their connections, it is probable that the water will prove too fresh in which to raise oysters of good quality, if, indeed, they could be grown at all.

After establishing the planted beds of brood oysters there should

be no difficulty in securing a set of spat on shells or other cultch laid down in the vicinity, or the shell-beds might be first established and the brood oysters scattered over them in the proportion of 25 to 40 barrels per acre. There are perhaps several hundred thousand barrels of shells on and around the small islands on the western side of Grand Lake. These are clean and bright and in excellent condition for planting, and moreover may be obtained for the labor of loading them on the boats, which may be run close against the bank, so that the labor of loading may be reduced to a minimum. These shells are small, averaging 1 or 2 inches in diameter, and as comparatively few spat would probably attach to each, the labor of culling would be much less than if large oyster shells are used, when often a hundred young attach to a single shell and the oysters grow in large clusters.

The amount of bottom suitable for oyster-culture is comparatively limited, especially if we except from consideration the extinct oyster reefs. What should be done with the latter is a matter worthy of consideration. As they now are, they are worthless tc everybody. It is only here and there that an adult oyster can be found, and even the few old shells remaining upon them are fast disappearing, owing to the attacks of boring organisms, worms, sponges, and lamellibranchs, which are rapidly bringing about their disintegration and decay. In the course of time the shells will become dissolved and entirely disappear, and eventually, with the deposit of sediment, the bottom will become almost, if not quite, as soft as the surrounding mud. The young oyster, as has been frequently pointed out in the publications of the Fish Commission and elsewhere, is extremely minute at the time it settles down from its free-swimming existence, and a very slight deposit of silt or slime is often sufficient to prevent its attachment to the hard bodies which are its only salvation. The shells upon these old reefs are now more or less completely covered with slime and sediment, whereas upon a thrifty reef there are always many comparatively clean shells to be found.

Each year that passes makes it more and more improbable that these reefs will ever become rehabilitated, and even now the condition of the shells is such that it is doubtful if oyster fry would find them suitable places for attachment, and the time will certainly come when all hope of nature again establishing beds must be utterly abandoned. In their present condition, however, they appear to be very well adapted to planting purposes, and it appears to be good economics to permit their use for this purpose rather than to still hug the almost certainly vain hope that nature will again step in and renew her bounties, and, waiting thus too long, lose the opportunity to make some salvage from the wreck which wasteful and improvident methods have already wrought.

Under a proper system of private culture these same reefs, now worthless, could probably be made to yield a product far greater than they ever did under the joint administration of nature and the natural-bed oystermen. It is a just and proper regulation that prohibits plant-

ing on the natural reefs or that forbids their alienation from the use of the public, but a law which practically says "once an oyster-reef always an oyster-reef" is contrary to the best interests of a State and her citizens.

OYSTER-PLANTING IN LA FOURCHE PARISH.

In Timbalier Bay most of the planting is done in the northeastern side, in the vicinity of Jack's Camp and at Camp Malnommé. In Little Lake no oysters are planted, but an extinct oyster-reef there is sometimes used as a temporary bedding-ground where oysters are freshened during periods of excessive salinity in the more open waters. In Bayou Landry and in Jack's Camp Bay one association of individuals is said to hold 120 acres of planting-ground, of which 60 acres are affirmed by the oystermen to be upon productive natural reefs which were regularly worked up to the time that the grounds were staked off as a private reservation under the laws relating to planting. It is impossible to form an opinion as to the merits of a controversy of this character without a careful investigation, as the decision hinges largely upon a question of veracity between the contending parties. This incident emphasizes the necessity for more definite laws regarding the occupation of the natural reefs for planting purposes.

Just what constitutes a natural reef is a matter which will receive a variety of interpretations, and some authoritative definition, even although it may be somewhat arbitrary, should be promulgated for the guidance of those intrusted with the enforcement of oyster regulations. The importance of making legal recognition of the fact that oyster-reefs may, under certain conditions, cease to be such, beyond reasonable hope of redemption, is pointed out in the discussion of the prevailing conditions in Barataria Bay. On the other hand, the contention and dissatisfaction among the oystermen at Jack's Camp shows there is danger in a too lax interpretation of laws prohibiting the individual occupation of natural beds to the exclusion of the public. Without expressing any opinion as to the merits of the special case cited, it may be emphatically pointed out that the State should safeguard from invasion those beds which it holds in common for the use of its citizens, as otherwise the favored few are permitted to reap the benefits which justly belong to the many.

A number of persons in addition to those associated in the case above cited are also engaged in oyster-culture on a small scale at Jack's Camp and Camp Malnommé. The practice is confined almost exclusively to the planting of seed from the natural beds, but some of the men spread a few shells along shore in the vicinity of their camps and afterwards transfer the young oysters to their beds in deeper water. The set of spat so obtained appears to be sufficiently abundant to amply warrant the further development of this practice, especially as the natural reefs are less productive than heretofore.

OYSTER-PLANTING IN TERREBONNE PARISH.

In Terrebonne Bay there are but few men planting oysters as compared with the large numbers engaged in fishing on the natural reefs. In the parish of Terrebonne, which includes the greatest and most productive oyster region in the State, there were but 32 oyster-planters to whom licenses had been granted in 1898, although it is stated that next season there will be a very material increase in the number, there being about 50 applicants now waiting for the survey of their beds. Of the 32 planters whose claims are registered there are not over 15 in Terrebonne Bay, the rest of them being in the bays and lakes lying to the westward. Most of the planting consists in the bedding of seed obtained from the many natural reefs in the bay. Comparatively few shells are planted, notwithstanding that at least 100,000 barrels are piled around the oyster-canneries at Houma, where they could be obtained for little or nothing and carried on the boats returning from that place to the oyster-beds. Most of the planted oysters are in the bayous and coves in the northern part of the bay. They are said to reach marketable dimensions when about 3 years old.

In Pelican Lake, a branch of Pelto Bay, there are several camps with bedding-grounds protected by stockades or fences. On the flats there are a great many raccoon oysters which are worthless in their present condition, but which might be utilized with profit for planting purposes. Such oysters when culled and planted upon good bottom undergo great improvement both in shape and condition, and in a year should be fit for market and hardly distinguishable from those which grew under good conditions from the start.

In Wilson Bay the oysters are said to get fat early in the season, and as the natural beds there are nearly exhausted it is quite probable that this would prove a good field for an attempt at planting.

In Lake Chien planting began about five years ago, when the natural reefs were approaching depletion, and there are now three or four private oyster-beds. Most of these are on the original natural reefs, which afford about the only hard bottom in the lake. A few shells are planted, but most of the seed is obtained from the raccoon oyster-beds in the surrounding bayous. When placed in deeper water, these inferior oysters improve very much in shape and flavor and are ready for market in about a year from the time of planting. They are said to get fat in September, but at the time the lake was visited (March, 1898) they were but moderately fat, although of very fair flavor. Both drumfish and snails are here very troublesome at times.

At Bayou de Large there are several men engaged in oyster-planting, small oysters being planted one year and marketed the next; and in Sister Lake and King Lake, both included in Lake Caillou as shown on the charts, some of the men engaged in oystering on the natural reefs have small planting-grounds.

Jack Stout Bayou and Bayou Provençal are considered the best

planting-grounds in this vicinity, as the oysters get very fat there early in the season. These bayous lie to the eastward of Bayou Taylor, which leads to the sea from the southwestern end of King Lake.

The maps of this part of the coast are extremely imperfect, and it is impossible to say which of the charted bayous are those now under discussion.

Seed oysters are obtained from Big and Little Bays Genope (or Genoble?) and from Lake Washa (Mauchas) and planted on the old reefs or on hard mud, the former being considered best for the purpose. When ready for market they are taken up, cleaned, and rebedded upon hard, clean bottom for from 3 to 7 days to wash and purge of dirt before being sent to market. Oysters are planted on a small scale in other bayous in the vicinity. Very little use of cultch is made by the planters in this region. They depend almost entirely upon the natural reefs for their seed, and instead of assisting the perpetuation of the natural oyster supply they aid in its destruction. At the mouth of Taylor Bayou there are great banks of shells on the outer coast readily accessible and well adapted for use as cultch. If this material were utilized properly, it would soon become unnecessary to obtain seed from the natural beds, and the problem of perpetuating the reefs would present a much more hopeful aspect.

SPAWNING OF THE LOUISIANA OYSTER.

If we may judge from the size of the spat which is found adhering to hard bodies on the oyster-beds, a set occurs during almost every month of the year, but the principal spawning season is between April 1 and September 15, although, for reasons which are not explicable by the facts at command, there appears to be considerable local variation in the time at which the climax is reached. The investigations made, although they are not entirely conclusive, point to the fact that the oysters west of the river in general ripen before those on the east side. During the last week in February the oysters of St. Bernard Parish showed no indications of the near approach of the spawning season, only an occasional individual emitting a few ripe eggs, while a week or ten days later a considerable proportion of those west of the river, in Plaquemines Parish, were decidedly "milky."

The same variation in the time of cessation of spawning was noticed. During the last week in August the oysters in Bayou Cook were still spawning rather copiously, those in Bay Adam had evidently just concluded, while those at Salt Works Canal were found to be fat and well conditioned, indicating that spawning had been over for several weeks, as it is not until the bulk of the spawn has been discharged that the oysters begin to fatten. In St. Bernard Parish they were found to be spawning freely at Three-mile Bayou and at Grand Pass on the 31st of August.

The oystermen say that spawning begins, or as they state it "the oysters become milky," when the water begins to decrease in salinity

under the influence of the spring freshets, and that it ceases with the influx of salter water in the fall. A change in the salinity of the water may perhaps stimulate reproduction, but it happens that the water is more and not less dense during the summer, when the oyster is spawning copiously, than it is in winter when only sporadic cases of sexual activity prevail.

The following table shows in condensed form the conditions prevailing at several places during the latter part of August, 1897:

Locality.	Date.	Density.	Remarks.
Grand Pass, St. Bernard Parish	Aug. 31	1.0176	Spawning freely.
Three-mile Bayou, St. Bernard Parish	...do	1.0123	Do.
Salt Works, Plaquemines Parish	Aug. 25	1.0151	Not spawning.
Bay Adam, Plaquemines Parish	Aug. 24	1.0076	Do.
Bayou Cook, Plaquemines Parish	...do	1.0106	Spawning.

It will be seen that there is no relation shown between the density of the water and the cessation of spawning, and that the relative as well as the absolute densities at the different seasons are not determining factors is seen when we consider the geographical relations of Bayou Cook and Bay Adam. No increase in salinity could take place in the latter, where spawning had ceased, without having a prior effect upon the former, where spawning still continued. At the same time it is apparently a well-established fact that in certain places, e. g., Salt Works, Wilson Bay, Bayou Provençal, and others, the oysters cease spawning and become fat very early in the season. Closer investigation would doubtless show that this was not due to one, but to a variety of causes, embracing density, temperature, and amount of food matter available.

The young fry of the oyster, which freely swims in the water, is often wafted long distances and widely distributed by the currents, a fact which accounts for the establishment of new beds and the frequent rejuvenation of old ones which have been destroyed. An instance of the latter, in Quarantine Bay, is noted in another connection in this report. In order that these minute fry may succeed in establishing themselves, it is necessary that they should find some clean, solid body to which to fasten, a fact that must be borne in mind when considering the question of oyster-culture and the use to be made of exhausted beds, such as are found in Barataria Bay.

RATE OF GROWTH OF LOUISIANA OYSTERS.

In the waters of Louisiana the oyster reaches a good marketable size within three years of the time of its fixation, this fact being established not as the result of more or less loose estimates, but from authentic data established by experience. It is rarely possible to determine with accuracy the age of oysters upon the natural beds, but occasionally circumstances arise which make such determinations

nearly accurate. A case of this kind occurred in Plaquemines Parish in 1897, when the oysters in Quarantine Bay and its vicinity were killed by a crevasse, which occurred about March 15 and lasted until July, when the water again became salt enough to support oyster life, and a heavy set of spat fell upon the dead shells. On March 2, 1898, when these beds were examined, much of this spat had grown to a length of from $2\frac{1}{2}$ to 3 inches, and, assuming that the water became suitable for oysters as early as July 1, these oysters could not have been older than 8 months.

In Bayou Schofield some oyster shells, put down about July 1, were taken up about August 15, and were found to bear spat, some of which was an inch in length. Shells planted in Bay Coquette in September, 1897, were taken up March 5 and found covered with young oysters, most of which were from 2 to $2\frac{1}{4}$ inches in length, although there were a few as small as $\frac{5}{8}$ inch.

At the same place, oysters grown on shells planted September, 1896, and culled and rebedded when about 1 year old, had grown to a length of about $3\frac{1}{2}$ inches by the 5th of March, 1898, when they could not have been more than 18 months old. They were of excellent shape and fine flavor. In July or August, 1895, a piece of rock about 6 or 8 inches in diameter was thrown upon the planting-ground in Bayou Schofield, being removed 23 months later. It is now in the possession of the United States Fish Commission and is covered with a growth of 40 or 50 oysters, all of which are over 4 inches, some of them being as much as 6 inches in length, but all rather inferior in shape owing to the crowding to which they were subjected. Tabulating these results we have the following as illustrating the normal rate of growth of oysters on favorable bottom in Louisiana:

Locality.	Age.	Length.
Bayou Schofield	Not over 6 weeks	$\frac{3}{4}$ to 1 inch.
Bay Coquette	Not over 6 months	2 to $2\frac{1}{4}$ inches.
Quarantine Bay (natural reef)	Not over 8 months	$2\frac{1}{2}$ to 3 inches.
Bay Coquette	Not over 18 months	$3\frac{1}{2}$ inches.
Bayou Schofield	Not over 23 months	4 to 6 inches.

It will be noticed that the length of some of the oysters 8 months old was but $\frac{1}{2}$ inch less than those 18 months old, but owing to the improvement in shape, due to the broadening and deepening of the shells, the animals in the latter were from 4 to 6 times as voluminous as the former. Had they not been culled from the shells and separated from one another the improvement would not have been so great, a statement illustrated by the 23-months-old specimens from Bayou Schofield. There are very few places in the North where the rapidity of oyster growth rivals that attained in Louisiana, a condition brought about by the abundance of oyster food induced by the favorable temperature and the richness of the waters in the chemical elements necessary for the production of vegetation.

DESTRUCTIVE AGENCIES.

Conch, Snail, Borer.—The mollusk which is known by these names on the coast of Louisiana is the *Purpura floridana* of naturalists. It causes considerable damage at times to both the planted and the natural beds, especially those located nearer the sea where the prevailing density of the water is higher, as it appears to be much more susceptible to the effects of fresh water than the oyster itself. There is a difference of opinion among the oystermen concerning the manner in which this mollusk destroys the oyster, some contending that it bores a hole in the shell like the northern drill, and others that it injects between the lips of the shell a substance which possesses the power of paralyzing the oyster and causing the shell to gape so as to permit access to the interior. Some of the oystermen pointed out what they considered to be the borings of this snail, but they were merely the bottoms of the chambers made by Martesias, the upper portions having disappeared by the delamination of the shells.

During the entire period of the investigations, although many bushels of oysters and dead shells were examined, not a single drilled oyster shell was noted, although several *Polinices* shells showed the handiwork of some boring gasteropod.

A number of specimens of *Purpura* were kept in aquaria with oysters, but in no instance did they molest them in any way. The theory that they inject a poisonous fluid into the oyster can be set aside as improbable, and there can be little doubt that they destroy their prey after the manner of their relatives, among which can be numbered the destructive drill, *Urosalpinx*, of Chesapeake Bay. This form, by means of its rasp-like tongue, bores a small hole in the shell of the oyster, through which it introduces its proboscis and extracts the soft parts. *Urosalpinx* feeds upon small oysters only, but the conch of the Louisiana oyster-bed, owing to its greater size and strength, could doubtless attack much larger individuals with success. It is said that extensive beds are sometimes practically depopulated by this animal, and the oystermen of St. Bernard Parish hold it responsible for the destruction of the oysters of Chandeleur Sound and for the present rather sparse population of Cabbage Reef. It is found everywhere on the oyster-beds of Louisiana excepting the less saline waters. It breeds in spring, its eggs being inclosed in vase-shaped capsules, attached to hard bodies in the water. Its numbers could doubtless be materially reduced were the oystermen to carefully destroy all animals and their eggs which they may take in the course of their work. Apparently little attention is paid to this matter, and most of the snails caught are thrown back on the beds with the culls and dead shells, to continue their destruction and to perpetuate their kind.

Drumfish.—The drumfish is one of the most destructive enemies of the oyster, and in Louisiana its depredations are especially annoying, inasmuch as they are largely confined to planted beds of single oysters.

On the natural reefs, where the oysters grow in clusters, the denseness of the growth and the sharp edges of the shells make it difficult for the fish to wreak much destruction, although the smaller clusters of young oysters are frequently eaten, being crushed and swallowed, shell and soft parts alike. The lips of drumfish caught on and near the oyster-beds are lacerated from contact with the knife-like edges of the young oysters. The oystermen working on the natural reefs often suffer considerable loss by having eaten the culled and cleaned oysters which are temporarily bedded, and frequent cases are reported of the loss of 30 or 40 barrels of bedded oysters within a single day. To prevent these inroads on the bedding-grounds the oystermen encircle them with old seines supported on pickets, or lines to which rags are attached are used to frighten the fish away, and in some places substantial stockades are constructed.

The drumfish is troublesome on nearly all of the planting-grounds in the State, but it appears to be especially so at Bayou Cook. The damage done to planted beds is usually wrought very soon after the separated and culled oysters are laid down. After several days have elapsed the oysters seem to be immune, probably either because they have sunk slightly in the mud on which they are planted or because they become more or less covered with sediment, which makes them less conspicuous. If the drumfish can be kept off for a week or two there appears to be but little danger of an attack thereafter, but if for any reason the oysters are rebedded the same difficulty is encountered as before.

To prevent depredations on the beds fences and stockades are erected, differing in dimensions only from the more substantial structures on the bedding-grounds. The drumfish operates in water of all densities, often occurring in that which is almost fresh and where the conch would never occur. It is most abundant and destructive during the months of September and October, but does some damage during every season except winter.

Stone-cracker.—The oystermen of Port Eads complain of the depredations of a large ray, known as the stone-cracker. Judging from the description of its general appearance and the large size which it is said to attain ("about 25 feet across") this appears to be the devil ray or devil-fish, *Manta birostris*, which is not uncommon on the coast of Louisiana. A planter at Port Eads states that he lost 300 barrels of oysters in two weeks through the depredations of this fish, and that he was at first unaware of the agent which caused this destruction, but finally saw 5 or 6 of them in the act. This species is not reported as an oyster enemy at any other place on the coast of Louisiana.

Stone-crab.—The stone-crab, *Menippe mercenaria*, is said to sometimes kill a good many oysters, especially the young ones under 3 inches long, breaking off the edges of the shells and extracting the contents. This enemy was reported from Quarantine Bay, Bayou Cook, and Bayou Coquette, and their connected waters. As a rule, it does not

occur in sufficient numbers to cause very great damage, but one man stated that he had had almost an entire lugger-load of oysters, from 2 to 3 inches long, destroyed by an unknown enemy, which had crushed the thin edges of the shells. The appearance of specimens of shells taken in Quarantine Bay and said to resemble those just mentioned leads to the suspicion that the destruction was wrought by the crab under discussion, the entire distal halves of the shells being wrenched and crushed.

Boring-sponge.—Upon the oyster-beds of Louisiana occurs a boring-sponge closely related to, if not identical with, the *Cliona sulphurea* found on the oyster-beds of the North. *Cliona sulphurea* in its mature stage forms large yellow masses sometimes more than 6 inches in diameter. During the investigations in Louisiana waters none of these massive forms were found, but many of the dead shells and some of the living ones were honeycombed by the galleries of the young sponges, which sometimes projected, as mushroom-shaped papillæ, nearly a quarter of an inch above the surface of the shells. This was particularly the case on the extinct reefs of Barataria Bay and other places west of the Mississippi River, where it occurs usually associated with the coral, *Astrangia danæ*, exactly as it does in places on the Atlantic coast. It is thought that this sponge does little harm to the oysters of Louisiana, but, in connection with the boring mollusk *Martesia*, it performs an important function in cleaning the reefs of old shells, which it corrodes and dissolves as its galleries extend. By the combined action of these forms the old reefs are practically eradicated in the course of a short time, and unless they become restocked with spat within 3 or 4 years they are placed beyond the possibility of natural rejuvenescence by the destruction of the cultch. It is rather remarkable that this sponge does not attack the shells on the shell-banks, such as are found in Barataria Bay.

Martesia cuneiformis.—This form is extremely abundant on the coast of Louisiana, especially upon the oyster-beds of St. Bernard Parish. It is a small species of boring-clam, which, during infancy, bores into the oyster shells, excavating a tiny cell from which it does not again emerge. As the clam increases in size the cell is enlarged, eventually becoming an egg-shaped cavity half an inch in its major axis and communicating with the exterior by a small pore about $\frac{1}{20}$ inch across. Often these are so closely arranged as to be almost in contact, and the oyster shell is so weakened that the outer part will scale off with a slight blow. This delamination appears to often take place naturally, the bases of the ovate chambers showing on the remaining parts of the shell as a collection of rounded pits, often mistaken by the oystermen for either incipient or abortive borings of the snail, *Purpura*. These animals can not be classed as true enemies of the oyster, and, in fact, they do it practically no injury, as the chambers rarely penetrate the shell, and even then are readily closed, and the delamination spoken of is not sufficiently profound to seriously injure the shell. The oyster

shell is used solely as a protection and a place of abode and without design upon the fleshy parts of the oyster, the food of the *Martesia* being found in the incurrent streams of water passing through the external orifice of the chambers.

Algæ.—Two species of algæ, which have not been identified, are found upon the oyster-beds of Louisiana. One of these is a species of *Ulva*, a green form with expansive fronds, its appearance well meriting its popular names of "sea lettuce" and "sea cabbage." This is quite abundant in some places during the summer, but seems to die down in winter. It appears to cause no serious annoyance to the oystermen as it is readily removed from the shells. The second is a species of *Florideæ*, which maintains a luxuriant growth throughout the winter. It consists of purplish-brown, slender-branching filaments, growing in dense tufts upon the shells. While it in no manner injures the oysters, except so far as it serves as a basis for the collection of mud and silt, it is a source of great annoyance to oystermen on account of the difficulty of its removal, and it not infrequently happens that fishing on a bed is temporarily abandoned because of its abundance. If oysters are sent to the markets or canneries with this seaweed attached the filaments almost certainly become mixed with the meats and fluids and render the opened product almost worthless.

Crevasses.—Practically the entire oyster region of Louisiana is so situated with respect to the Mississippi River as to be subject to the influence of crevasses occurring at almost any part of its course south of the mouth of the Red River. In 1890 great damage was caused by the Nita crevasse, which discharged through Blind River into Lake Maurepas, and thence via Lake Pontchartrain and Lake Borgne into Mississippi Sound. This affected the oysters in St. Bernard Parish and Mississippi Sound as far as Biloxi.

In the spring of 1897 the river broke through the levee at Bohemia, and, in a minor degree, at other places on the east bank of the river, and killed all the oysters in the vicinity of Quarantine and California bays; and several years ago the Pass à Loutre crevasse, which has not yet been closed, produced a similarly disastrous effect in Garden Island Bay. Instances might be multiplied, but those noted are probably the most striking ones occurring within the last few years.

The effects of a crevasse are twofold; it deposits mud and freshens the water, both of which are more or less disastrous to the oysters. Crevasses occur during periods of high water, when the river is carrying large quantities of materials scoured from its watershed, and when this sediment-laden stream strikes the salt water, either at its mouth or through a temporary discharge resulting from a crevasse, its velocity is checked and the mud in suspension is deposited, while at the same time the salt water precipitates certain materials which have entered into actual solution. When these materials are thrown down upon the oyster-beds the oysters are smothered and the shells buried.

In some cases the deposit of mud may be slight or the swiftness of the currents of fresh water pouring out to sea may actually exert a scouring action, carrying off the deposit of sediment which is normally thrown down in the comparatively still waters of the bays and bayous, and leaving the shells exposed and clean, even though the animals be killed by the abnormal freshness of the water.

When the deposit of mud is excessive the prospects for recuperation are poor, as the young oysters, even though they be wafted on the currents into the devastated region, can find no place for attachment. On the other hand, when the oysters are killed by the fresh water the shells are often left in excellent condition to serve as cultch, and oyster fry carried in from afar finds abundant facilities for fixation. This appears to have been the case in St. Bernard Parish after the Nita crevasse, and was certainly so in Plaquemines Parish after the breakage in the levees at Bohemia. In the latter instance, soon after the subsidence of the water, the spat began to set thickly upon the shells, and at the time of our investigation there was a very dense growth of young on all of the beds examined, although hardly an old one was to be found.

As was found by conversation with oystermen at many places, there is a general belief among them that a crevasse will always rehabilitate an exhausted oyster region, owing to the production of oyster spawn by the interaction of the fresh and salt waters. This idea is based upon false reasoning from the facts just set forth. It is extremely improbable, for instance, that the beds of Barataria Bay would be again rendered productive by a crevasse, because there are but few oysters in the vicinity to furnish the spawn, and the cultch, or material to which the young could attach, has been almost destroyed by boring organisms of several kinds. Without these the influence of the crevasse is of no avail, as its benefits are in all probability due entirely to the mechanical effects of the currents to which it gives rise.

RECOMMENDATIONS.

In consideration of the observations and conclusions set forth in the foregoing report the following recommendations are made:

1. That no oysters be permitted to be removed from the natural beds for any purpose whatever during the period from April 15 to October 1.

This regulation is intended not so much to protect the spawning oysters, which would, of course, result incidentally, as to protect at least some of the young oysters from injury at a time when they are exceedingly delicate and when, owing to their small size and fragility, it is almost impossible to cull them from the marketable oysters as defined by the culling laws. By allowing them an additional month's growth, under the favorable conditions obtaining in Louisiana, a larger number should have reached a size permitting of their detachment from their places of fixation.

2. No oysters, wheresoever caught, should be sold or exposed to sale within the close season as fixed in the preceding section.

This prohibition is regarded as the most feasible method of enforcing the close season in the absence of a large and expensive oyster police. If all States should adopt legislation along this line it would solve the question of the enforcement of close seasons. It is similar to the regulation which has been found most efficient in protecting game and fish. It would doubtless cause some inconvenience and loss to dealers and restaurateurs who now sell oysters, presumably from without the State, during the close season, but it is doubtful if they would suffer to a greater extent than they would under a strict enforcement of section 7, Act No. 121, General Assembly, 1896.

3. It should be illegal to remove from the natural beds, for any purpose whatever, shells or oysters under 3 inches in length. All oysters caught on the natural beds should be culled upon the beds whence they are taken and all shells and oysters less than 3 inches long, as measured from hinge to tip or nip of shell, should be promptly returned to the beds.

Regulations in regard to culling oysters are considered the most important and efficient measures which can be adopted for protecting the natural beds, as close seasons can not be relied upon to prevent their extinction. It has often been demonstrated that it is quite possible to utterly "clean up" a bed within the limits of a short close season, and the writer knows of cases in Louisiana in which beds of limited extent were practically bared of oysters within two or three days by a small fleet of boats, each anxious to get the largest possible share of desirable oysters recently discovered. If all the oysters be caught up in two days, two weeks, or two months, it is useless to close the beds during the rest of the season. If, however, the culling law be strictly enforced there will always be a crop of young oysters growing up to take the place of the old ones carried to the markets, and if the minimum limit be placed at 3 inches, as recommended, there will always be some of these capable of spawning. In August, 1897, oysters of that size were found to be sexually active on the beds of St. Bernard and Plaquemines parishes.

The minimum limit here recommended is one-half inch greater than that provided for in the present laws of Louisiana and most other States. It is believed that this increase is highly essential to the welfare of the natural reefs, and as oysters less than 3 inches long bring but a small price in the markets, it is regarded as unjustifiable to sacrifice the future for an insignificant gain in the present. As a matter of fact, many of the oystermen voluntarily reject all the oysters under the size recommended, and there is no good reason why all should not be compelled to do so. By increasing the cull limit two ends are gained—a larger number of oysters must be left on the reefs and a larger proportion of these will be capable of spawning during the following period of reproductive activity. The law would be incomplete and unsatisfactory, however, were it to prevent the taking of young oysters for the market and yet allow them to be taken for use as seed.

The provision of section 8 of the oyster act of 1896, "that nothing in this section shall deprive the police juries of the parishes in which natural oyster beds or bars are situated of the privilege of granting permission for the removal of shells or small oysters to other parishes in the State for planting purposes," is one which would allow the utter destruction of the natural beds, however wise and stringent the rest of the law might be. The culling law as it stands defeats its own ends. Whatever the purpose to which young oysters may be devoted, their removal must be injurious to the parent beds. Nature takes cognizance of immediate rather than mediate results, and does not inquire into motives when her laws are infringed upon. It is an interesting fact, and one not without significance, that the natural beds first exhausted in Louisiana are those nearest the most extensive planting-grounds.

Doubtless the curtailment of the present privilege possessed by planters of taking young oysters from the natural beds would bring forth a protest, but this should not stand in the way of a rational administration of the oyster laws. The regulation here suggested does not prevent the taking of oysters for seed, but only prescribes the size of seed which it shall be legal to take from the natural reefs, and there is still a reasonable profit to be derived by bedding oysters not less than 3 inches long. The planter's profit arises not only from an increase in quantity due to growth, but also from a great increase in the value bulk for bulk—the larger oysters are more valuable than the seed, while the planted oysters, owing to their generally superior shape and condition, are more highly valued than the natural growth.

It is, moreover, much to the planter's interest to have the natural beds preserved, and any reasonable measure, such as is here suggested, should receive his support. The extermination of natural beds means increasing difficulty in procuring seed, either large or small, a point well illustrated by the experience of Bayou Cook planters, who since the destruction of the Barataria Bay beds have been compelled to go to Timbalier Bay, involving the payment of canal tolls and increasing the distance by about 20 miles.

Even should the proposed regulation practically prohibit oyster-planting as now carried on, it would be preferable to enforce it rather than to permit the extermination of the natural beds, for that in itself would result in the destruction of both. This conclusion is justified when it is remembered that there is another and more valuable method of oyster-culture open to the planters, the system of planting cultch, which will be described hereafter. The planting of seed oysters does not greatly increase the productiveness of the oyster lands. It improves the size, shape, and flavor of the plants, and to a limited extent increases the oyster output by saving some which would perhaps fall victims to the vicissitudes of life on the natural beds, but in the main it merely transfers the immediate source of the product from the public to private beds without lessening the drain upon the former.

4. All boats or vessels engaged in culling should be at anchor on the natural beds.

This proviso is intended to aid in the enforcement of the preceding one requiring culling upon the reefs. It will prevent the practice, more or less common, of saving time by culling the oysters while under way to market, with the result that the culls often fall upon unsuitable bottom and are destroyed, whereas they would have been saved had they been culled on the reefs.

5. Every effort should be made to induce the oystermen to adopt the practice of exposing shells or other cultch for the purpose of catching the spat or young oysters. This method of culture is now carried on to a limited extent in some parts of Plaquemines Parish, as may be seen by reference to that section of this report which deals with the subject of oyster-planting. It not only results in an improvement in the quality of the oysters, as in seed-planting, but also in a very important increase in the quantity. If generally adopted it would result in saving millions of oysters which now perish in the soft mud and ooze for lack of places for attachment, and every oyster so saved is an oyster added to the product of the State.

By this method of oyster-culture the planter makes himself independent of the natural reefs; he raises his own seed oysters and there is no necessity or supposititious necessity of carrying away the young growth from the public beds. At the same time there is a reduction in the quantity of natural-reef oysters needed for the markets, part of this demand being satisfied by the oysters from the planted beds, and finally these planted beds would directly benefit neighboring natural beds, especially if these be somewhat exhausted, by furnishing large quantities of fry to aid in their recuperation. From every point of view, therefore, it is advantageous to encourage the planting of cultch, but unless private enterprise be sufficiently keen to appreciate its opportunities it is difficult to see how Louisiana planters can be induced to undertake it. Probably the best means for bringing this about would result naturally from the curtailment, as heretofore recommended, of the present too liberal policy in regard to the taking of seed from the natural reefs. If the men be not allowed to take small oysters and shells promiscuously, and if they be compelled to cull off the oysters less than 3 inches long, precisely as if they were taking them for the markets, it will doubtless make them more alive to the advantages of planting shells. It is hoped that this, with the aid of more liberal regulations in regard to planting recommended hereafter, will induce an increase in the acreage of planting beds and promote the use of cultch rather than seed from the natural beds. It is believed that after one or two men have demonstrated the advantages of the method suggested the others will not be slow to follow. In many places, as has been pointed out in the section dealing with oyster-planting, there are large quantities of shells available on the spot, and when this is not the case shells, broken tiles, or other suitable materials may be brought,

with but little labor or expense, by the boats returning from the markets.*

The recommendations which follow are mainly aimed to offer all reasonable facilities and inducements for the extension of the system of oyster-culture advocated above.

6. It is suggested that provision be made for granting to the oyster-grower permanent tenure of his beds. He should be permitted to hold them, subject to the rights of navigation, under provisions similar to those under which he might hold lands above tide. The first cost should be nominal, say $1 per acre and the cost of making the survey; and the tax thereafter should not be more than a fraction of the annual rental now levied on the leased lands. It would, perhaps, be advantageous to allow the planter the option of purchasing under the above conditions or of leasing on liberal terms. The end to be kept in view is to induce persons to undertake oyster-culture, and not the immediate production of a large revenue for the State or parish. It is believed, however, that under more liberal provisions a larger number of persons would engage in the industry, and that both directly and indirectly this would result in an increase in the revenue derived from the oyster industry, besides adding to the individual prosperity of the citizens of the State. In March, 1898, there were but 32 grants of oyster-lands in the parish of Terrebonne—which has the most extensive oyster-lands of any parish in the State—yielding not over $80 yearly each to State and parish under present laws. This is a small matter, indeed, to stand in the way of regulations fostering what is likely to prove a great industry, and which at the same time would do much to perpetuate the value of the public oyster-lands.

7. The area which may be purchased or leased by each applicant should be increased from 10 to at least 25 acres, and doubtless it would be good policy to remove the limit entirely. The policy of restriction is unreasonable and illogical, and few would advocate it with reference to lands above tide, its consequences there being obvious. If it be considered, however, that a limit to individual holdings be desirable, it should be remembered that when the shells are planted it will take about a year longer for the oysters to reach a marketable size than if yearling seed from the natural beds be used, and that the planter therefore requires a larger area upon which to produce a given annual crop.

8. It is recommended that a definition be made of the meaning of the term "natural oyster reef or bed" as used in the oyster laws, and that this definition be drawn with due regard to the fact that a reef may cease to be such, either as a result of oystering or in consequence of the operation of purely natural causes. The reasons for this recommendation are set forth on pp. 85 and 86 of this report, where they are considered in connection with certain concrete cases which fell under the observation of the writer. It is recognized that a definition of

*The methods usually employed are explained in detail in "Oysters and Methods of Oyster-culture," in Report U. S. Fish Commission for 1897.

what constitutes an oyster-reef must be to a certain extent arbitrary in character, and the following is offered as tentative and is designed especially for the conditions prevailing in Louisiana:

A natural oyster reef, bar, or bed is an area of not less than 500 square yards of the bottom of any body of water upon which oysters are found or have been found within a term of five years immediately preceding the time at which the questions concerning said bottom are decided, in quantities which would warrant taking them for profit by means of tongs.

The reasons for the several provisions of the definition are as follows: The minimum limit of 500 square yards is placed in order that small or insignificant patches of oysters within the limits of otherwise available planting-grounds shall not, under the provisions of the oyster law, debar an applicant from having such bottom assigned to him as a private planting-ground. The term of five years is established because it is believed that within that time, under the conditions existing in Louisiana, a depleted oyster-reef will either have become regenerated or else be beyond hope of redemption by natural agencies, and there will be no reason for further exempting it from occupation as planting-ground. The final provision is to prevent an extinct reef from being regarded as a natural bed for the purposes of the oyster act, merely because it contains a few scattered oysters which could not be taken for the markets with profit.

9. It is suggested that the oyster laws might in some places be enforced better, as they certainly would be, throughout the State, more uniformly, if their administration were placed in the hands of a State fish commission appointed for that purpose. There are some parts of the State in which the oyster fishery is apparently subject to no supervision whatever, except that now and then the vessels engaged in it are called upon to pay a tax.


APPROXIMATE LOCATION
of the
OYSTER BEDS
OF ST. BERNARD PARISH
LOUISIANA
From a reconnaissance
made by the U.S. Fish Commission Steamer "Fish Hawk"
Lieut. Franklin Swift, U.S.N., Commanding
Feb 1898
Scale
Note
The Soundings are shown in black and give depths in feet
Densities are shown in blue figures
Dense growths of oysters are shown thus
St. Joseph I.
MISSISSIPPI
SOUND
LIVE OAK
BAY

THE SHAD FISHERIES

OF THE

ATLANTIC COAST OF THE UNITED STATES.

BY

CHARLES H. STEVENSON.

SYNOPSIS.

THE SHAD FISHERIES OF THE ATLANTIC COAST OF THE UNITED STATES.

By Charles H. Stevenson.

INTRODUCTION.

According to the returns of the United States Fish Commission there were 24,768 men employed in the shad fisheries of the Atlantic coast of the United States in 1896; the boats, apparatus, etc., employed were worth $2,040,342, and the yield of shad numbered 13,053,429, valued at $1,651,443. These figures include only the common shad (*Alosa sapidissima*), and not the several related species known as hickory shad winter shad, mud shad, jack, etc.

The capture of shad is occasionally reported from certain of the tributaries of the Gulf of Mexico, but it does not exist in those waters in sufficient abundance to maintain important fisheries. The several plantings made from time to time have resulted in colonizing shad in nearly all the rivers of the Pacific slope from San Pedro to Puget Sound, and the annual yield on that coast approximates 200,000. In addition to the United States coast, the species is also caught on the eastern coast of the British North American provinces as far north as the Gulf of St. Lawrence, the yield approximating 600,000 annually.

There is no species of fish more important to the residents of the entire Atlantic seaboard than the shad, and none whose preservation so immediately concerns a larger number of persons. The yield of codfish is larger and of greater value, but the fishery for that species is confined to one section of the coast, gives employment to less than half as many men, and its prosecution requires costly vessels and appliances, necessitating lengthy trips from port and much exposure and loss; whereas shad occur more or less abundantly along the entire coast, ascending the rivers as far as they permit, almost to the very doors of fishermen and consumers several hundred miles from the sea, and are caught by all forms of apparatus, from the costly seines and pound nets near the coast to the roughly constructed bow nets and fall traps in the headwaters of the rivers.

However, there are few fishes whose geographical range and local abundance are more easily affected by agencies of man, and during the last fifty years the shad fisheries have undergone great changes. In the early part of the present century these fish ascended the numerous streams until they reached the headwaters or met with impassable falls, and they were caught all along the river course, every point yield-

ing its quota for local use. Not only did this method of reaching the consumers have many advantages over the present, but it also gave opportunity for a large percentage of the shad to spawn in suitable places and thus keep up the supply. There was no concentration at any particular point, and the limited local demand did not warrant the prosecution of the fisheries so vigorously as to cut off the run at points above.

Dams were gradually constructed along the streams, completely blocking the passage to the spawning-grounds in the upper reaches. Then the concentration of the fisheries near the mouths of the rivers resulted, in certain narrow streams, in excluding shad almost entirely from the middle and upper parts, restricting or entirely preventing the reproduction of the species in those rivers. The excessive fisheries and the destruction of spawn by sewage and by washings from cultivated fields, and of young shad by improper modes of capture, make heavy drains upon the natural abundance of these fish. In a number of streams on the Atlantic seaboard the fisheries have been entirely destroyed by these combined agencies, and in most of the others the number of shad that reach the spawning areas has been so far reduced that natural reproduction is yearly becoming less effective in keeping up the supply, and the necessity for artificial hatching becomes proportionately greater.

The history of the shad fisheries shows that there was a decrease in the yield in nearly every river on the coast until 1880, when the results of artificial propagation became apparent, not only maintaining an equilibrium, but increasing the abundance. Since 1880 the aggregate yield has greatly increased, the product in 1896 being 28 per cent greater than in 1888 and nearly three times as great as in 1880. And yet 1896 was what is commonly termed an "off" year for shad, the catch being smaller than in 1895 or in 1897. It should be noted, however, that this largely increased yield has been accompanied and even surpassed by an increase in quantity and effectiveness of the apparatus of capture, but it was made possible by the results of artificial propagation. Comparing 1880 with 1896, it is observed that the increase in the yield numbered 7,905,154. At 25 cents each, the average price paid by consumers, this represents an increase of $1,976,288 in the value, over 60 times the expenditure for shad propagation, a result probably unsurpassed in any other line of fish-culture.

The supporting of profitable shad fisheries is not the only object to be gained in maintaining the supply of shad on the coast. The relation between the different species of fish in the economy of nature is not very well understood, but sufficient is known to indicate that the valuable shore fisheries on the New England coast are intimately associated with the run of shad and similar species up the rivers of that section. Seventy years ago the run of fish up the rivers of the New England States was very much greater than at present, and after the parent fish had disappeared the waters swarmed with the young, which

later in the year descended to the sea in enormous schools, attracting the cod, haddock, and other offshore species, which were caught in great abundance within a short distance of the coast, rendering unnecessary the expensive and hazardous trips to distant banks. But with the depletion of shad, alewives, salmon, and kindred species came a corresponding diminution in the number of cod, haddock, etc., near the coast. And it appears that any measures tending to restore the anadromous fishes to their former abundance will also improve the coast fisheries.

Another subject requiring attention is the conflicting laws regulating the shad fisheries in contiguous waters, and frequently in the same waters when under the jurisdiction of more than one State. Many of the most important shad streams either form the boundary line between two States or they traverse more than one State, thereby subjecting them to more than one system of regulations. Thus in the Delaware River there are three systems of regulations operative, viz, those of New Jersey, Pennsylvania, and Delaware. In the Potomac there are likewise three jurisdictions, viz, Maryland, Virginia, and the District of Columbia. The regulations of the shad fisheries on the New Jersey side of the Hudson River conflict with those on the New York side of that stream. Also in such rivers as the Pee Dee, Susquehanna, and Connecticut, which traverse more than one State, there is usually considerable friction between citizens of the two States because of alleged injurious methods of fishery being permitted in each end of the river.

The main object of this report is to attract more attention to the shad fisheries, to the necessity for improvements in the passage of shad to the headwaters of the rivers, for continued and increased efforts in the line of artificial propagation, and to the desirability of having uniform regulations in the various waters possessing similar physical conditions. It relates exclusively to the fisheries on the Atlantic coast of the United States and contains no reference to the important results accomplished in introducing shad into the waters of the Pacific coast, nor the even more interesting subject of the possibilities of stocking the Mississippi River and tributaries. The general condition of the fisheries and kindred subjects are first discussed, and these are followed by a description of the fisheries of each water area.

In the preparation of this report use has been made of all available material, acknowledgment being given in cases where other reports or publications have been extensively quoted. From the reports of the United States Fish Commission and the State commissions, as well as those of the Chief of Engineers, United States Army, so many data have been obtained that it would be useless to attempt to refer in detail to the authority for each statement therefrom when not of particular importance. The writer has personally visited and investigated the shad fisheries of most of the water areas of the Atlantic coast at some time during the past nine years, and the result of those observations is embodied in this report.

The statistics herein given, showing the extent of the shad fisheries in 1896, which is the year referred to in this report when not otherwise mentioned, were obtained by agents of the United States Fish Commission. Valuable assistance has been received from Messrs. Ansley Hall, John N. Cobb, and H. O. Weaver, of the Commission.

MIGRATIONS OF SHAD.

The shad belongs to the migratory class of fishes, being found in the coastal waters during only a portion of each year. In their annual migration mature shad appear in the southern rivers of the United States in December and January, and as the season advances they appear successively in the various streams, reaching the New England waters about May 1. After remaining in the rivers several months they disappear, renewing the performance the following season.

The young fry, hatched out in the rivers in spring and early summer, remain there until the following fall, when they leave for the ocean, and nothing more is seen of them until they return to the estuaries as mature or nearly mature fish, supposed to be two or three years old. Their habitat from their disappearance on the coast in the summer and fall to their reappearance in the following winter or spring is unknown. It is likewise unknown whether, as they disappear from the estuaries, they remain nearby or go far off from the shore, or whether they retreat in a direction parallel with the coast to the warmer waters of the South. Neither has it been established whether individual shad visit the rivers every year or every two years, but the depletion by casualty and capture is so great that probably only a small proportion ever ascend the rivers a second time.

In accordance with the old-time theory that all seasonal migrations were directed toward and from the equator, it was formerly considered that the entire body of shad wintered in the South and started northward in a vast school at the beginning of the year, advancing along the coast in almost military array, sending a detachment up each successive stream, this division, by a singular method of selection, being the individuals that were bred in those respective streams, the last portion of the great school entering the Gulf of St. Lawrence.

But zoologists now recognize a second kind of seasonal movement, termed "bathic migration," by which uniformity of temperature is secured far more readily than by moving toward or from the equator; and the present theory is that the young shad hatched out in any particular river remain within a moderate distance off the mouth of that stream until the period occurs for their inland migration, and that the schools of fish are generally distributed off the coast at all times, entering the rivers as soon as the temperature of the water is suitable. Their appearance first in the extreme southern river of the coast, the St. Johns, and at later dates successively in the more northern rivers, seems to confirm this view. There are exceptions to this order of

appearance. For instance, the Ashepoo and Edisto rivers are many miles north of the Altamaha or the Savannah, and yet the run of shad in the former is usually coincident with the run in the two latter. Explanation of this is found in the fact that the Ashepoo and the Edisto rise in the sand hills and swamps, while the two latter streams have their sources in the mountains of northern Georgia and South Carolina; consequently at a given date the waters of the two former are warmer than those of the Altamaha or Savannah. Hence it appears that the season of migration is determined by the temperature of the water rather than by geographical location.

The following summary shows for the principal water areas of the Atlantic coast the approximate dates at which shad fishing began in 1896:

Waters.	Date.	Waters.	Date.
St. Johns River	Dec. 1	Chesapeake Bay—continued.	
Altamaha River	Jan. 10	Rappahannock River	Mar. 18
Ogeechee River	4	Potomac River	7
Savannah River	6	Nanticoke River	13
Edisto River	7	Choptank River	14
Santee River	15	Susquehanna River	Apr. 14
Winyah Bay	11	Delaware Bay	Mar. 13
Cape Fear River	21	Delaware River	Apr. 1
Pamlico Sound	Feb. 3	New York Bay	Mar. 30
Neuse River	5	Hudson River	Apr. 1
Pamlico River	6	Long Island Sound	10
Albemarle Sound	4	Connecticut River	13
Roanoke River	Mar. 14	Narragansett Bay	2
Chowan River	8	Casco Bay	25
Chesapeake Bay, lower end	Feb. 26	Kennebec River	May 1
James River	Mar. 6		
Chickahominy River	10		

While the principal motive for, or rather the chief result accomplished by, the migration of shad into the rivers is the reproduction of the species, yet it appears that their movements are more immediately governed by the comparative temperature of the waters than by the approaching ripeness of the spawn. For instance, although they enter the St. Johns about December 1, spawning does not take place there until some time in March or April. In the sounds of North Carolina, and in Chesapeake and Delaware bays, shad enter a month or two before they begin to spawn. But in more northerly streams, as the Connecticut and Kennebec, where the entrance of the fish is delayed by low temperature caused by melting ice flowing down the river, spawning occurs shortly after the shad enter.

An interesting fact in connection with the migratory movements of shad is the arrival of the males several days before the females. This appears common to all the waters of the coast, the bucks constituting nearly two-thirds of the catch during the first third of the season and the roes being equally predominant during the last third.

The great bulk of shad appearing in the rivers are mature fish, weighing 2 pounds and upwards, and averaging about 3 pounds for the males and $4\frac{3}{4}$ pounds for the females. But in the lower portion of the estuaries and along the coast there are numerous schools of smaller

fish, commonly known on the New England coast as "sea shad," which usually appear somewhat later than the grown fish. Excepting in the St. Johns River, Delaware River, and on the New England coast, comparatively few of the small fish are caught unless unusually low temperature prevails in the rivers during the fishing season.

A subject about which there is much disagreement is whether shad spawned in a certain river return or endeavor to return to the same stream on their reappearance from the sea as mature fish. This idea has been quite generally accepted, and has to some extent furnished arguments for the prosecution of the work of artificial propagation. Not only has it been contended that shad return to the river basin in which they were spawned, but that they endeavor to return to the same locality in that river basin. In a letter written by Professor Baird in 1873 to the Hon. Hamilton Fish, then Secretary of State, the following statement is made:

> Anadromous fish, or such as run up the rivers from the sea to spawn, will return, if possible, to the river in which they first saw the light. So true is this that where there may be two or three rivers entering the sea in close proximity, which have become destitute of shad or herring in consequence of long-continued obstructions, and the central one only has been stocked by artificial means, the fish, year by year, will enter that stream, while those adjacent on either side will continue as barren of fish as before.

While this may be true to a certain extent, yet, as Professor Baird says in the same letter:

> It is difficult to imagine how a shad spawned in any northern stream could avoid entering a more southern river if in its vicinity.

It seems that fish spawned in Kennebec River are more likely to return to that stream than they are to Delaware River, and that shad fry planted in the latter stream will tend to improve the fisheries of that section rather than those of the waters of Georgia. But how is it in case of two rivers in close proximity, like the Ogeechee and Savannah, whose entrances into the sea are only 17 miles apart? The young shad leaving those rivers and remaining in the deep water off the mouths thereof for a period of two or three years must surely commingle as a result of currents, variations of temperature, search for food, etc. Again, in the instance of two or more streams which communicate with the sea through the same outlet, as the Neuse, Chowan, and Roanoke rivers, all of which are tributaries of Pamlico Sound, or the various tributaries of Chesapeake Bay, does the peculiar instinct common to shad cause them to pass by the mouth of one stream and enter another merely because, three years before, they were spawned in that other river? It appears more reasonable to suppose that shad remain in the hydrographic area in which they are spawned, this area including the rivers entering the sea and the submerged areas between the coast line and the Gulf Stream, and that they seek any suitable spawning-grounds within that area and do not necessarily return to the identical river in which they were bred. When shad were introduced

in the Sacramento River it was supposed that they would return only to that stream, but they have since appeared in many of the Pacific coast waters in which they had not been indigenous and had never been planted.

Those who believe that shad return to the identical river in which they were spawned refer to the numerous instances in which the fisheries of a certain river have decreased after the shad have been excluded, by means of dams, from the spawning areas in that stream. But those decreases appear to be due rather to the general depletion of shad in that coastal area. For instance, the Merrimac River was obstructed in 1848 by a dam at Lawrence, 25 miles from the sea, yet shad were caught in considerable abundance below that dam for a period of thirty years thereafter, and the decrease in the Merrimac appears to be merely an incident of the decrease on the New England coast. This decrease is apparent in Casco Bay, where neither obstructions nor spawning-grounds have ever existed. Comparatively few shad ascend the Savannah or the Pee Dee as far as the spawning-grounds, yet the fisheries of those streams appear to be holding their own among the rivers of the South Atlantic States.

It is well known that in their passage through the coastal waters shad pursue certain well-defined paths, which, however, may be varied by unusual conditions of temperature or currents. Thus, in passing up the lower end of Chesapeake Bay shad usually crowd the western shore, and are caught in immense numbers in the pound nets set there, while the nets on the opposite shore take very few, this being due to their following the thread of fresh water entering from the western side of the bay. Yet during certain seasons, when quantities of cold water are flowing down the Virginia rivers, or during the prevalence of northwest winds, shad are caught in considerable abundance on the eastern shore of Virginia and those nets on the western shore take comparatively few. In entering Connecticut River, shad appear to follow the shore west of the mouth of that stream, where they are caught in considerable numbers for a distance of 10 or 15 miles, yet they are rarely caught on the shore immediately east of the river. In this instance they are attracted by fresh water flowing from the Connecticut, which appears to pursue a southwesterly course immediately on leaving that river.

After entering the estuaries the rate and course of the shad movement up the rivers are influenced by various causes, which are thus described by the late Commissioner McDonald:

If, in consequence of warm rains at the river source, the temperature of the water becomes suitable to the shad at an earlier date than usual, then their upward movement takes place very rapidly, and, we may say, tumultuously, the great schools of fish crowding in and moving up all at once, so as to produce what is termed a "glut." If, however, the temperature of the water rises by insensible degrees with the advance of the season, then the upward movement begins when the water temperature of the river has passed above that of the sea, and takes place gradually, the rate of movement in such cases being slow and the period prolonged. Again, when the shad have entered the rivers, the temperature conditions being such as to deter-

mine a rapid upward movement, yet should the fish encounter floods and consequent muddy waters, their upward movement is arrested, the schools back down before the flood, and, if this condition is prolonged, may be driven entirely out of the river. In short, fluctuations in the river temperature have corresponding influences upon the shad movements; any sudden change, whether to a higher or lower temperature, apparently arrests their upward course for a time, and sometimes even determines a retrograde movement. Many of the anomalies which perplex fishermen in the course of their work may be explained by the varying movements of the fish as controlled by the water temperature in the rivers. We find, for example, that while at a particular seine shore during one season a very large catch is made, yet in the following season the fishery in the same locality may prove a failure, although the general run of fish in the river has not diminished. If we suppose a seine to sweep the flats at the mouth of such a stream as the Occoquan Creek (a tributary of the Potomac River), and if we further suppose that the river waters in the channel are colder than, or as cold as, the waters of the Chesapeake Bay, the shad in their movement up the river would avoid the main current and would slowly work their way up the shores and over the flats, where the temperature of the waters will be found to be, under such circumstances, several degrees warmer than in the channel. Such a season would be profitable to a seine sweeping the flats. Again, if the waters in the main channel of the river were of suitable temperature, then the upward movement of the shad would take place in the channel and not along the flats. Under such circumstances a channel seine would make a very large catch, while a seine hauled over the flats would probably find very indifferent fishing.

In their migrations up the rivers shad ascend the stream until the volume of the water forming the channel of the river becomes quite inconsiderable, or, as is more frequently the case, until their movements are arrested by impassable falls, dams, or other obstructions. However, a discussion of the limit of their range in the rivers is reserved for a special chapter.

RANGE OF SHAD IN THE RIVERS.

In considering the limit of shad range in the rivers the principal points to be kept in view are the size of the stream, uniformity of slope, and its freedom from dams and other obstructions. No river on the Atlantic seaboard appears too long for shad to ascend to its headwaters, provided they meet with nothing to bar their progress. At present they ascend the St. Johns, in Florida, a distance approximating 375 miles; the Altamaha 300 miles; the Santee 272 miles; the Neuse 270 miles, and the Delaware River a distance of 240 miles from the sea. However, these distances do not equal the extreme ranges in the early part of the present century. Then shad ascended the Savannah to Tallulah Falls, a distance of 384 miles, instead of 209 miles as at present. They ran up the Pee Dee to Wilkesboro, a range of 451 miles, whereas the present limit on that river is Grassy Island, 242 miles from the sea, and only one shad was reported from that point in 1896. On James River the former run was 350 miles in length, while the present limit is at Bosher's Dam, 120 miles. But the greatest decrease exists in Susquehanna River, in which shad formerly ascended to Binghamton, 318 miles from the mouth and 513 miles by watercourse from the sea, whereas at present they do not appear to pass beyond Clark's Ferry, 84 miles from the mouth of the river.

The following summary shows, in comparative form, the original and the present limit of the shad range in 23 of the principal rivers of the Atlantic seaboard:

Rivers.		Distance of sources above coast line.	Original limit of shad run.		Present limit of shad run.	
			Locality.	Distance from coast line.	Locality.	Distance from coast line.
		Miles.		*Miles.*		*Miles.*
St. Johns		375	Sources	375	Sources	375
Altamaha		450	Macon	370	Hawkinsville	300
Ogeechee		350	Ogeechee Shoals	200	Millen	100
Savannah		425	Tallulah Falls	384	Augusta Dam	209
Edisto		300	Sources	300	Jones Bridge	281
Santee	Wateree	350	Great Falls	272	Great Falls	272
	Congaree	410	Green River	374	Columbia	233
Pee Dee		497	Wilkesboro	451	Grassy Island	242
Cape Fear		290	Haywood	210	Smiley Falls	181
Neuse		340	Sources	340	Fish Dam	300
Pamlico-Tar		252	Rocky Mount	157	Rocky Mount	157
Roanoke		457	Weldon	249	Weldon	249
James		420		370	Bosher's Dam	140
Rappahannock		248	Falmouth Falls	155	Falmouth Falls	155
Potomac		400	Great Falls	190	Great Falls	190
Susquehanna		617	Binghamton	513	Clark's Ferry	279
Delaware		457	Deposit	256	Burrows Dam	196
Hudson		314	Glens Falls	209	Troy	164
Housatonic		202	Falls Village	150	Birmingham	92
Connecticut		409	Bellows Falls	204	Windsor Locks	89
Merrimac		140	Winnepesaukee	125	Lawrence	20
Kennebec		155	Carritunk Falls	108	Augusta	44
Penobscot		255		90	Verona	35

It appears that in 23 of the principal rivers, aggregating 8,113 miles in length from the coast line, shad formerly existed throughout 6,052 miles, or 72 per cent of the length, whereas at present they are to be found in only 4,203 miles, a decrease of 1,849 miles. This summary comprises only the principal rivers, and if the minor streams and tributaries were included, the total length from which shad have been excluded would doubtless appear more than twice as great. In much of that length shad were quite numerous, the catch in many instances exceeding the yield in the part to which the fisheries are now confined. The upper section of the Pee Dee is supposed to have yielded over 100,000 annually. In James River, according to the late Commissioner McDonald, the annual catch of shad in the 230 miles from which they are now excluded "was at one time far in excess of the now (1880) entire catch for the whole river." The present excluded length of the Susquehanna formerly yielded several hundred thousand annually. In a report of special commissioners of Massachusetts, appointed in 1865 to investigate the fisheries of that State, it was estimated that at the beginning of the present century the annual shad yield in Merrimac River ranged from 500,000 to 1,000,000 in number, whereas none ascend that river at present.

The limitation in the range of shad in the rivers is the result of several agencies in addition to the size of the stream, the most important of which are (1) natural falls, (2) insurmountable dams, (3) pollution of the water, (4) agricultural operations, and (5) extensive fisheries.

Natural falls exist at the escarpment line in all of the rivers having their sources above the coastal plane, but in only a few instances are they of sufficient height to form insurmountable obstacles to the range of shad, among these being Weldon Falls on the Roanoke River, Great Falls on the Potomac, and Bellows Falls on the Connecticut, all of which form absolute barriers to the further progress of shad that may reach those points, excluding them from the whole of the river above. Most of the other Atlantic coast streams having their sources above the coastal plane have been made impassable at or a short distance above the escarpment line by means of artificial dams for developing water-power or for navigation improvements. In this class are the Savannah, the Santee, the James, the Susquehanna, the Housatonic, the Connecticut, the Merrimac, the Kennebec, and the Penobscot, the lengths from which shad are excluded appearing in the aforegoing table.

Numerous attempts have been made by the erection of fishways to enable shad to pass above these obstructions, among the costly contrivances of this nature being those in the Savannah at Augusta, the Santee at Columbia, the Potomac at Great Falls, the Susquehanna at Clark's Ferry, the Housatonic at Birmingham, the Connecticut at Holyoke, the Merrimac at Lawrence, and the Kennebec at Augusta. And although these are modern constructions, designed by engineers of ability, familiar with the principles of hydraulics and the habits of fish, none of them appears to be successful for shad, this fish being so timid that it will not enter fishways readily used by salmon, alewives, and other species. True, a few individuals may pass through some of them, but the number is not sufficiently large to be of any practical value, and in a majority of instances where shad are reported above a dam they have swum over the crest during freshets or they have passed through breaks in the obstruction.

Access to suitable spawning areas being necessary for the maintenance of the fisheries if natural reproduction is depended on, and as many of the spawning-grounds are located in the headwaters of the rivers, it follows that while the exclusion of shad from the upper sections is the immediate it is not the most important effect of those obstructions. It has been the common experience in all the shad rivers that whenever a high dam or other obstruction has been erected across the stream the fisheries above that point have at once ceased, and those immediately below have for a year or two flourished on the large number whose ascent has been stopped by the barrier, and then they too have declined. It also appears that the extent of this decrease below the dam is largely dependent on the nearness of the obstruction to the mouth of the river and the proportion of the spawning-grounds to which they are denied access, and if all the breeding-grounds have been cut off in a definite coastal region the shad have almost entirely disappeared.

This is clearly illustrated by the conditions in Connecticut River. The erection of the Holyoke dam in 1849 prevented the fish from

ascending above that point, and as they strayed about in the river below the obstruction they were taken in greater abundance than formerly. At the Parsonage fishery, near the mouth of the river and 40 miles below the dam, the shad yield during the twenty years preceding the erection of the obstruction averaged 9,854 annually; during the five years following 1849 the annual catch averaged 19,490; during the next ten years it was but 8,364, and for the following six years, 1865–1870, the annual average was but 4,482 shad, less than one-half the former yield. The record of the catch on the Connecticut from 1853 to 1896 shows that the total yield below the dam decreased from nearly 500,000 annually to an average of less than one-tenth of that number. In a few rivers the development of water-power has resulted in completely exterminating the anadromous fishes, this being the case in the Thames, the Blackstone, the Merrimac, the Saco, and other rivers. However, instead of the employment of a few hundred persons in taking fish each spring, the water-power on those streams affords employment to thousands of mill operatives.

The utility of the spawning areas below the dams has also been impaired by chemicals, sawdust, and other refuse from mills and towns on the river banks. In a number of small streams these have almost completely destroyed the spawning and breeding areas, but regulations against this practice now exist in many States.

Another factor having some effect on limiting the range of shad up the rivers is the increased agricultural operations. At the time of the settlement of the river valleys most of those areas were covered with forests, and the ground was carpeted with leaves and moss, which checked the surface flow of water and restricted its evaporation, thus tending to constancy in the flow of rivers, and freshets were rare and of insignificant proportions. With increase of population the forests were cleared away and large areas of land brought under cultivation, causing injurious meteorological changes and more numerous and destructive floods. During heavy rains the plowed soil upon the hillsides is easily washed into gullies through which the cold water is quickly conveyed to the rivers, filling them beyond their capacity and bringing into them masses of earth and other débris, thus covering the spawning-grounds. The freshets are soon over, and the flow of water in the streams becomes so small that shad are not induced to proceed so far up as formerly.

On some of the Southern streams decreased navigation has resulted in reducing the length of shad range. This is especially true of the Combahee, the Ashepoo, the Edisto, the Chickahominy, the Mattaponi, and the Pamunkey, the channels of which are now encumbered with drifting logs, overhanging trees, brushwood, and shoals of loose, shifting sand, through which a passageway for the ascent of fish was formerly maintained by navigation and the rafting of timber.

The most important factor in reducing the inland range is the extensive fisheries near the coast. In the first half of the present century

shad were caught all along the river course, every point yielding its quota for local use and the limited demand not warranting the prosecution of the fisheries so vigorously as to cut off the "run" at points above. But the profit derived from shipping shad to distant markets has caused a concentration of the fisheries at points near the mouths of the rivers where convenient shipping facilities exist, resulting, in certain narrow streams, in practically excluding shad from the middle and upper sections where the spawning-grounds are located. The effect is not so apparent as in the case of impassable dams and natural falls, for the latter form absolute barriers, whereas extensive fisheries merely limit the number of fish ascending to the extreme range of the river and not the length of that range. Yet, in many cases they affect the future abundance of the species even more than the dams and natural falls. This is especially noticeable in those narrow streams whose fluvial characteristics extend nearly or quite to the sea, as in most of the rivers between the St. Johns and the Neuse, and to some extent in the Susquehanna, the Hudson, the Connecticut, etc. In the Ogeechee, Savannah, Edisto, Pee Dee, and Cape Fear, the great bulk of the catch is obtained in the extreme lower end, within 30 or 40 miles of the sea, and comparatively few shad ascend as far as the spawning-grounds. In the Connecticut nearly all the shad are caught within 20 miles of the mouth. In those rivers the dams perform a very unimportant part in limiting the run of fish, for few shad ever reach those obstructions. In the broad estuaries tributary to the sounds of North Carolina and to the Chesapeake and Delaware bays the effect of the large quantities of twine is not so apparent; yet, even in those waters only a small percentage of the shad reach the spawning-grounds.

EXTENT OF THE SHAD FISHERIES IN 1896.

The extent by States.—The following tables show the extent of the shad fisheries of the Atlantic coast of the United States during the season of 1896. First is presented a series of three tables showing, by States, (1) the number of persons employed; (2) the boats, apparatus, etc., used, and (3) the number and value of shad taken, and these are followed by three other tables showing similar data for each watercourse. From these it appears that of the 23,128 shad fishermen in 1896, 8,793 operated drift nets; 2,703, stake nets; 4,840, seines; 3,076, pound nets and weirs; 3,926, bow nets, and 253 operated fyke nets and miscellaneous apparatus. In addition there were 1,445 shoresmen, 195 transporters, and also many persons operating apparatus in which shad were taken incidentally. The boats, apparatus, etc., employed aggregated $2,040,342 in value, and the catch of shad numbered 13,053,429, of which 5,998,143 were taken in drift nets, 1,703,099 in stake nets, 1,999,942 in seines, 3,139,830 in pound nets and weirs, 123,803 in bow nets, 73,410 in fyke nets, and the remaining 15,172 were taken by spears, fall traps, etc.

Statement of the number of persons employed in the shad fisheries of the Atlantic coast of the United States in 1896.

States.	Fishermen.								Shoresmen.	Transporters.	Total.
	Drift-net.	Stake-net.	Seine.	Pound-net and weir.	Fyke-net.	Bow-net.	Miscellaneous.	Total, exclusive of duplication.			
Florida	357	20	110	......	......	......	......	487	31	5	523
Georgia	504	210	......	3	......	226	......	888	......	......	888
South Carolina	551	145	95	......	......	863	*a* 14	1,646	......	......	1,646
North Carolina	566	999	1,357	690	......	2,514	*b* 17	5,957	930	60	6,947
Virginia	1,609	443	444	1,497	12	......	*c* 9	3,946	42	73	4,061
Maryland	1,663	474	1,009	689	93	256	*d* 8	4,116	381	17	4,514
Delaware	415	14	252	6	......	16	......	699	......	......	699
Pennsylvania	353	......	681	......	......	51	*e* 30	1,115	16	2	1,133
New Jersey	1,784	311	574	......	36	......	......	2,701	35	38	2,774
New York	729	87	250	34	14	......	*e* 20	1,106	10	......	1,116
Connecticut	138	......	53	5	......	......	......	190	......	......	190
Rhode Island	......	......	......	6	......	......	......	6	......	......	6
Maine	124	......	15	146	......	......	......	271	......	......	271
Total	8,793	2,703	4,840	3,076	155	3,926	98	23,128	1,445	195	24,768

a 8 wheel, 6 cast-net. *b* Wheel. *c* 3 hedge, 6 fall-trap. *d* Fall-trap. *e* Spear.

Statement of the boats, apparatus, etc., employed in the shad fisheries of the Atlantic coast of the United States in 1896.

States.	Boats.		Drift nets.			Stake nets.			Seines.		
	No.	Value.	No.	Length (yards).	Value.	No.	Length (yards).	Value.	No.	Length (yds.).	Value.
Florida	251	$9,384	191	91,550	$17,350	10	850	$200	24	7,150	$2,175
Georgia	495	7,023	280	36,994	11,788	148	3,288	1,292	......	......	......
South Carolina	799	14,603	271	85,947	15,490	128	8,390	3,346	22	1,635	931
North Carolina	2,831	80,388	377	34,682	6,063	57,787	1,103,872	73,874	230	76,658	56,561
Virginia	2,028	77,058	1,370	298,043	25,998	9,378	90,214	10,949	42	24,361	19,005
Maryland	1,976	104,492	2,638	472,138	44,464	3,955	84,588	9,532	90	33,349	25,816
Delaware	350	15,645	309	107,361	12,971	7	2,700	240	68	8,307	3,187
Pennsylvania	468	21,340	173	70,770	11,028	......	......	......	96	19,305	12,285
New Jersey	1,180	101,908	848	546,807	94,518	2,627	56,826	16,131	87	19,190	14,663
New York	547	26,165	456	624,265	30,189	1,403	33,895	3,878	41	28,820	5,840
Connecticut	102	2,306	86	20,193	4,265	......	......	......	17	3,048	1,243
Rhode Island	3	90	......	......	......	......	......	......	......	......	......
Maine	281	11,642	228	56,298	2,870	......	......	......	*a* 2	1,230	370
Total	11,311	472,044	7,227	2,445,048	276,994	75,443	1,384,623	119,442	719	223,053	142,076

States.	Pound nets and weirs.		Fyke nets.		Bow nets.		Miscellaneous.		Shore property.	Total investment.
	No.	Value.	No.	Value.	No.	Value.	No.	Value.		
Florida	......	......	......	......	......	......	......	......	$4,349	$33,458
Georgia	26	$208	......	......	113	$259	......	......	2,817	23,387
South Carolina	......	......	......	......	447	1,155	*b* 83	$2,185	3,328	41,038
North Carolina	1,575	132,083	......	......	1,278	3,781	*c* 75	1,125	243,882	597,757
Virginia	1,156	236,680	72	$1,032	......	......	*d* 22	805	61,953	433,480
Maryland	901	66,816	335	5,223	128	625	*e* 15	600	53,524	311,092
Delaware	4	385	......	......	10	40	......	......	11,672	44,140
Pennsylvania	......	......	......	......	51	185	*f* 30	23	36,451	81,312
New Jersey	......	......	245	1,964	......	......	......	......	112,728	341,912
New York	12	3,630	54	955	......	......	*f* 20	20	7,130	77,807
Connecticut	......	......	......	......	......	......	......	......	955	8,769
Rhode Island	3	920	......	......	......	......	......	......	120	1,130
Maine	133	23,340	......	......	......	......	......	......	6,838	45,060
Total	3,810	464,062	706	9,174	2,027	6,045	245	4,758	545,747	2,040,342

a 1 purse seine, 960 yards long, worth $350.
b 3 cast nets and 80 wheels and fall traps.
c Wheels.
d 3 hedges and 19 fall traps.
e Fall traps or fish pots.
f Spears.

Statement of the number and value of shad caught on the Atlantic coast of the United States in 1896.

States.	Drift nets.		Stake nets.		Seines.		Pound nets and weirs.	
	No.	Value.	No.	Value.	No.	Value.	No.	Value.
Florida	333,277	$53,677	1,689	$285	125,248	$8,627		
Georgia	130,925	44,808	10,134	3,338				
South Carolina	83,233	19,405	33,602	6,615	4,262	1,107		
North Carolina	83,015	18,910	944,582	204,080	532,966	90,899	478,531	$90,690
Virginia	872,823	74,178	304,808	39,663	151,335	12,740	1,871,074	180,197
Maryland	695,651	68,875	129,034	14,959	223,351	24,499	449,567	52,658
Delaware	407,542	60,936	4,200	672	53,922	7,154	380	53
Pennsylvania	297,004	36,525			308,335	40,487		
New Jersey	2,586,381	249,763	191,275	29,095	466,439	45,790	40,377	6,720
New York	362,062	50,938	83,775	10,449	68,345	8,991	22,550	3,641
Connecticut	55,723	10,740			7,472	1,673	7,093	1,669
Rhode Island							12,472	3,284
Massachusetts	22,080	691			12,442	1,390	5,300	1,155
Maine	68,427	6,701			45,825	2,512	252,486	21,565
Total	5,998,143	696,147	1,703,099	309,156	1,999,942	245,869	3,139,830	361,632

State.	Fyke nets.		Bow nets.		Miscellaneous.		Total.	
	No.	Value.	No.	Value.	No.	Value.	No.	Value.
Florida							460,214	$62,589
Georgia			2,865	$1,125	50	$18	143,974	49,289
South Carolina			24,816	6,089	714	220	146,627	33,436
North Carolina			55,710	12,284	2,000	380	2,096,804	417,243
Virginia					3,463	277	3,203,503	307,055
Maryland	13,832	$1,361	27,612	3,940	2,003	259	1,541,050	166,551
Delaware			2,300	445			468,344	69,260
Pennsylvania			10,500	1,893	5,400	540	621,239	79,445
New Jersey	54,008	8,688					3,338,480	340,056
New York	5,600	699			482	115	542,814	74,833
Connecticut							70,288	14,082
Rhode Island					1,060	306	13,532	3,590
Massachusetts							39,822	3,236
Maine							366,738	30,778
Total	73,440	10,748	123,803	25,776	15,172	2,115	13,053,429	1,651,443

It appears that in the number of persons employed, North Carolina ranks first among the Atlantic coast States, this position being due to the large number of bow-net fishermen in the State. Next in order are Maryland, Virginia, New Jersey, and South Carolina. In the number of shad caught New Jersey stands first, with a yield of 3,338,480, and Virginia comes second, with 3,203,503 shad. Virginia usually ranks first, with North Carolina second, but the catch in those two States in 1896 was unusually small, while it was considerably above the normal in New Jersey.

The extent by water areas.—No regular shad fisheries are prosecuted along the ocean shore of the United States, and the great bulk of this species is taken within the general coast line. With the exception of a few individuals caught incidentally in the several pound nets along Virginia Beach, no shad are reported as obtained along the ocean shore south of Barnegat, N. J. Between Barnegat Inlet and Sandy Hook Point there are a hundred or so pound nets set for menhaden, flounders, bluefish, etc., which catch 10,000 or 15,000 shad annually. The next point at which shad are taken outside the general coast line is between the eastern end of Long Island and Cape Cod, where 3,000 or 4,000 are

caught each year in pound nets. Between Cape Cod and the eastern part of Maine mackerel boats catch several thousand shad, and a few are taken in pound nets set on the coast, 97,565, being thus taken in 1896, making a total of 115,676 shad taken in 1896 along the ocean shore, against a total of 12,937,753 taken within the coast line.

The following table shows by water-courses the number of persons employed in the shad fisheries in 1896:

Statement, by water areas, of the number of men employed in each branch of the shad fisheries of the Atlantic coast in 1896.

Water areas.	Fishermen.								Shoresmen.	Transporters.	Total.
	Drift-net.	Stake-net.	Seine.	Pound-net and weir.	Fyke-net.	Bow-net.	Miscellaneous.	Total, exclusive of duplication.			
St. Johns River	337		110					447	31	5	483
St. Marys River	80	30						110			110
Satilla River	7							7			7
Altamaha River	162	192				226		526			526
Ogeechee River	160							160			160
Savannah River	144	8		3			6	160			160
Combahee River		14						14			14
Ashepoo River		18				12		29			29
Edisto River		84	35			159		265			265
Cooper River		4	4			24		27			27
Santee River		25				110		132			132
Winyah Bay and tributaries	522		56			558	8	1,144			1,144
Cape Fear River	394		173			368		863			863
Pamlico Sound		368		82				450	13	20	483
Neuse River	76	156	408	58		1,026		1,653	28		1,681
Pamlico Tar River	46	24	189	16		230		463		5	468
Croatan and Roanoke sounds		86	30	76				192	29	5	226
Albemarle Sound		331	121	229				680	519	30	1,229
Roanoke River	36	2	169			870	17	1,094	67		1,161
Chowan River	14		190	191				395	239		634
Pasquotank and Perquimans rivers		32	77	38		20		167	35		202
Chesapeake Bay	516	194	316	875				1,891	282	69	2,242
James River and tributaries	678	166	108	12			3	967			967
York River and tributaries	599	113	62	94	10			870			870
Mobjack Bay				96				96			96
Rappahannock River	96	114	27	260	2		6	453			453
Potomac River	477	21	334	424		25		1,273	70	21	1,364
Nanticoke River and tributaries	316	32	100	31	26			487			487
Choptank River and tributaries	311	68	115	143	12			617			617
Susquehanna River	98		672		9	51	8	834	71		905
Miscellaneous	275	209	156	253	46	231		1,154			1,154
Delaware Bay	622	14	12	4				652		3	655
Delaware River	1,663		814				30	2,507	51	37	2,595
Miscellaneous rivers	173		218			16		407			407
Ocean shore of New Jersey		135	26		11			168			168
New York Bay	120	21		26	33			192	1		193
Hudson River	583	242	250		6			1,077	9		1,086
Long Island Sound	2			13				15			15
Connecticut River	94		36					130			130
Miscellaneous rivers	68		17				20	83			83
Narragansett Bay and tributaries				6				6			6
Casco Bay	20		11					31			31
Kennebec River and tributaries	83		4	146				219			219
Other Maine rivers	21							21			21
Total	8,793	2,703	4,840	3,076	155	3,926	98	23,128	1,445	195	24,768

The following table shows, by water areas, the boats, apparatus, etc., employed in the Atlantic coast shad fisheries in 1896:

Statement, by water areas, of the boats, apparatus, etc., employed in the shad fisheries of the Atlantic coast of the United States in 1896.

Water areas.	Boats.		Drift nets.		Stake nets.		Seines.		Pound nets and weirs.	
	No.	Value.	No.	Value.	No.	Value.	No.	Value.	No.	Value.
St. Johns River	221	$9,174	171	$17,050			24	$2,175		
St. Marys River	95	665	80	1,200	15	$300				
Satilla River	6	30	3	60						
Altamaha River	274	1,500	80	2,000	118	1,124				
Ogeechee River	84	3,200	80	5,000						
Savannah River	83	1,953	70	4,066	25	68			26	$208
Combahee River	7	280			14	410				
Ashepoo River	15	483			17	590				
Edisto River	127	2,490			62	2,184	12	485		
Cooper River	5	25			3	35	1	70		
Santee River	75	225			32	127				
Winyah Bay and tributaries	553	10,985	258	15,252			9	376		
Cape Fear River	437	2,644	224	4,735			43	1,239		
Pamlico Sound	235	21,650			24,808	30,001			171	13,885
Neuse River	838	12,240	38	676	3,424	3,945	110	7,153	87	10,378
Pamlico-Tar River	242	4,392	23	197	840	985	50	7,739	27	3,325
Croatan and Roanoke sounds	79	6,570			5,850	7,797	1	3,000	143	11,125
Albemarle Sound	319	23,622			21,985	29,944	4	12,500	612	56,215
Roanoke River	501	3,505	18	270	15	45	8	6,100		
Chowan River	120	3,375	74	185			8	12,600	447	29,530
Pasquotank and Perquimans rivers	60	2,390			865	1,157	6	6,230	88	7,625
Chesapeake Bay	897	84,948	1,087	21,079	2,286	5,701	7	10,400	631	151,242
James River and tribs	540	6,917	559	9,918	3,733	3,905	19	3,385	6	585
York River and tributaries	431	8,229	592	8,145	1,043	802	10	1,110	90	16,375
Mobjack Bay	34	3,615							76	15,570
Rappahannock River	272	9,847	101	1,780	3,263	3,859	5	810	231	37,957
Potomac River	520	24,895	236	12,385	529	1,043	13	17,700	430	43,350
Nanticoke River and tribs	220	3,644	333	5,808	282	684	20	1,380	40	3,075
Choptank River and tribs	301	4,640	571	5,844	1,469	2,500	22	2,360	194	12,141
Susquehanna River	331	29,011	223	3,403			63	8,670		
Miscellaneous	701	11,025	413	3,620	728	1,987	36	3,646	361	23,261
Delaware Bay	278	31,335	259	44,930	7	240	2	425	2	325
Delaware River	1,079	91,146	827	70,131			104	22,768		
Miscellaneous rivers	231	3,420	137	1,936			70	2,042		
Ocean shore of New Jersey	85	2,011			1,097	8,196	12	260		
New York Bay	94	7,605	106	6,560	302	1,510			6	2,200
Hudson River	516	23,679	337	23,425	2,631	10,303	41	5,840		
Long Island Sound	7	401	1	80					6	1,430
Connecticut River	59	1,200	48	3,321			12	863		
Miscellaneous rivers	55	1,346	50	1,068			5	380		
Narragansett Bay and tribs	3	90							3	920
Casco Bay	19	4,224	64	885			1	350		
Kennebec River and tribs	242	7,210	124	1,745			1	20	133	23,340
Other Maine rivers	20	208	40	240						
Total	11,311	472,044	7,227	276,994	75,443	119,442	719	142,076	3,810	464,062

Water areas.	Fyke nets.		Bow nets.		Miscellaneous.		Shore property.	Total investment.
	No.	Value.	No.	Value.	No.	Value.		
St. Johns River							$4,349	$32,748
St. Marys River								2,165
Satilla River								90
Altamaha River			113	$259			47	4,930
Ogeechee River							1,735	9,935
Savannah River					3	$7	1,718	8,020
Combahee River							50	740
Ashepoo River			6	15				1,088
Edisto River			83	231			350	5,740
Cooper River			24	68			100	298
Santee River			55	138			20	510
Winyah Bay and tributaries			279	703	80	2,178	2,125	31,619
Cape Fear River			184	480			7,710	16,808
Pamlico Sound							4,505	70,041
Neuse River			529	1,461			45,125	80,978
Pamlico-Tar River			120	305			7,200	24,143
Croatan and Roanoke sounds							15,448	43,940
Albemarle Sound							82,495	204,776
Roanoke River			435	1,515	75	1,125	34,267	46,827
Chowan River							36,002	81,692
Pasquotank and Perquimans rivers			10	20			11,130	28,552

Boats, apparatus, etc., employed in Atlantic coast shad fisheries in 1896—Continued.

Water areas.	Fyke nets.		Bow nets.		Miscellaneous		Shore property.	Total investment.
	No.	Value.	No.	Value.	No.	Value.		
Chesapeake Bay							$51,055	$324,425
James River and tributaries					3	$45	8,042	32,797
York River and tributaries	64	$842					4,430	39,933
Mobjack Bay							1,640	20,825
Rappahannock River	8	190			19	760	3,851	59,054
Potomac River			3	$6			21,525	120,904
Nanticoke River and tributaries	143	2,495					7,185	24,271
Choptank River and tributaries	57	550					11,088	39,123
Susquehanna River			59	209	15	600	6,723	48,616
Miscellaneous	135	2,178	117	595			5,818	52,130
Delaware Bay							26,240	103,495
Delaware River					30	23	121,721	305,789
Miscellaneous rivers			10	40			5,505	12,943
Ocean shore of New Jersey	31	650					55	11,172
New York Bay	248	2,164					2,425	22,464
Hudson River	20	105					6,055	69,407
Long Island Sound							100	2,011
Connecticut River							465	5,849
Miscellaneous rivers					20	20	490	3,304
Narragansett Bay and tributaries							120	1,130
Casco Bay								5,459
Kennebec River and tributaries							6,838	39,153
Other Maine rivers								448
Total	706	9,174	2,027	6,045	245	4,758	545,747	2,040,342

It will be seen that from St. Johns River to Cape Fear River, inclusive, shad are taken principally in drift nets, with smaller catches in set nets, bow nets, haul seines, and fall traps. Of 826,130 shad caught in that region in 1896, 602,244, or 73 per cent, were taken in drift nets; 140,912 by seines; 45,425 by set nets; 36,785 by bow nets; and 764 by fall traps and cast nets. The principal shad streams are St. Johns, Altamaha, Ogeechee, Savannah, Edisto, Pee Dee, and Cape Fear. The rivers of this section empty directly into the ocean, maintaining their fluvial characteristics almost if not quite to their outlets.

Next come Pamlico Sound and its important tributaries, Albemarle and Croatan sounds, and the Neuse, Pamlico, Roanoke, and Chowan rivers, etc. There the bulk of the catch is by stake nets, pound nets, and seines, the drift-net yield being of very small extent. In 1896, 944,582 were taken in stake nets, 521,564 by seines, 478,531 by pound nets, 46,606 by bow nets, 28,206 by drift nets, and 2,000 by fall traps.

The shad fisheries of Chesapeake Bay and its tributaries are the most extensive and valuable on the coast, the yield during an ordinary year approximating nearly half the total product of the United States. Although 1896 was an "off year" in the Chesapeake, the catch aggregated 4,867,619, nearly 33 per cent of the total yield on the coast. Of this product 2,320,921 were obtained by means of pound nets, 1,597,944 by drift nets, 433,842 by stake nets, 457,502 by seines, and the remaining 57,410 by means of fyke nets, bow nets, and fall traps.

Next comes the important estuary of the Delaware, the yield in which, including its tributaries, is usually about one-half that of the Chesapeake and tributaries. In 1896, however, the yield was somewhat greater than usual, 4,017,462 shad being taken, of which 3,261,457 were secured by drift nets, 744,005 by seines, and the remaining 12,000 by spears, stake nets, fyke nets, and pound nets.

Northward from the Delaware there are only three important shad streams, viz, the Hudson, Connecticut, and Kennebec, the yield in which, in 1896, numbered 588,898, 51,690, and 290,122, respectively. In the Hudson, the most important apparatus are drift nets, stake nets, and seines; in the Connecticut, drift nets and seines only are used; and the entire yield of shad in the Kennebec is obtained in weirs and drift nets. Besides these three rivers there are numerous small streams and coastal indentations in which more or less shad are caught each year.

The following statement shows the number and value of shad caught on the Atlantic coast in 1896:

Statement, by water areas, of the number and value of shad caught in each form of apparatus employed on the Atlantic coast in 1896.

Water areas.	Drift nets.		Stake nets.		Seines.		Pound nets and weirs.	
	No.	Value.	No.	Value.	No.	Value.	No.	Value.
St. Johns River	331,033	$53,297			125,248	$8,627		
St. Marys River	7,609	1,313	2,584	$441				
Satilla River	1,500	240						
Altamaha River	17,310	5,803	9,202	3,168				
Ogeechee River	55,425	19,514						
Savannah River	54,299	19,196	37	14				
Combahee River			3,090	622				
Ashepoo River			6,400	1,254				
Edisto River			21,967	4,281	2,634	640		
Cooper River			80	25	20	7		
Santee River			2,065	433				
Winyah Bay and tributaries	80,259	18,527			1,608	460		
Cape Fear River	54,809	13,950			11,402	2,747		
Pamlico Sound			387,236	96,249			60,853	$13,478
Neuse River	18,485	3,244	26,483	4,680	114,077	21,239	22,471	3,902
Pamlico-Tar River	5,221	1,139	8,114	1,632	38,693	7,439	7,759	1,538
Croatan and Roanoke sounds			73,626	15,090	20,000	3,800	75,915	14,311
Albemarle Sound			429,599	82,664	132,213	25,401	173,380	32,094
Roanoke River	4,000	480	6,100	1,195	143,809	16,043		
Chowan River	500	97			60,450	11,835	122,595	22,490
Pasquotank and Perquimans rivers			13,424	2,570	12,322	2,395	15,558	2,877
Chesapeake Bay	242,903	23,971	84,952	9,990	33,622	4,064	1,277,367	129,904
James River and tribs.	339,628	28,091	101,706	18,324	49,509	4,341	3,119	361
York River and tribs.	350,441	31,201	43,921	5,251	12,701	955	138,895	12,890
Mobjack Bay							140,777	13,874
Rappahannock River	40,354	3,157	104,118	8,242	9,740	973	262,504	22,916
Potomac River	279,280	23,188	11,510	1,616	123,445	9,853	269,228	28,801
Nanticoke River and tributaries	117,266	11,107	17,665	2,015	29,897	3,019	42,143	3,732
Choptank River and tributaries	120,261	12,625	35,275	3,813	67,245	7,478	115,041	11,838
Susquehanna River	35,540	3,949			90,444	13,832		
Miscellaneous rivers	72,271	8,689	34,695	5,371	40,899	5,023	71,847	8,573
Delaware Bay	1,098,821	103,996	4,200	672	700	74	100	19
Delaware River	2,086,791	226,795			686,612	73,263		
Miscellaneous rivers	75,845	13,508			56,693	7,194		
Ocean shore of New Jersey			200	50	865	378	13,675	2,715
New York Bay	63,500	7,620	52,275	8,329	1,010	223	42,332	5,880
Hudson River	297,178	42,958	222,575	31,165	68,345	8,991		
Great South Bay and Gardiner Bay							4,755	1,092
Long Island Sound	128	46			41	10	9,258	2,343
Connecticut River	45,851	8,244			5,839	1,264		
Miscellaneous rivers	11,128	2,810			1,592	399		
Ocean shore of Rhode Island							1,051	287
Narragansett Bay and tributaries					3,355	934	11,421	2,997
Buzzards Bay and Vineyard Sound							3,385	834
Cape Cod and Massachusetts bays	22,080	691			9,087	456	1,915	321
Casco Bay	6,110	355			40,325	2,017	18,055	1,208
Kennebec River and tribs.	50,317	5,434			5,500	495	234,305	20,328
Penobscot and other Maine rivers	12,000	912					126	29
Total	5,998,143	696,147	1,703,099	309,156	1,999,942	245,869	3,139,830	361,632

Statement, by water areas, of the number and value of shad caught in each form of apparatus employed on the Atlantic coast in 1896—Continued.

Water areas.	Fyke nets.		Bow nets.		Miscellaneous.		Total.	
	No.	Value.	No.	Value.	No.	Value.	No.	Value.
St. Johns River							456,281	$61,924
St. Marys River							10,193	1,754
Satilla River							1,500	240
Altamaha River			2,865	$1,125			29,377	10,096
Ogeechee River							55,425	19,514
Savannah River					70	$26	54,406	19,236
Combahee River							3,090	622
Ashepoo River			480	127			6,880	1,381
Edisto River			3,672	922			28,273	5,843
Cooper River			296	94			396	126
Santee River			5,244	1,114			7,309	1,547
Winyah Bay and tributaries			15,124	3,832	694	212	97,685	23,031
Cape Fear River			9,104	2,267			75,315	18,964
Pamlico Sound							448,089	109,727
Neuse River			25,536	6,002			207,052	39,067
Pamlico-Tar River			7,295	1,568			67,082	13,316
Croatan and Roanoke sounds							169,541	33,201
Albemarle Sound							735,192	140,159
Roanoke River			13,500	2,391	2,000	380	169,409	20,489
Chowan River							183,545	34,422
Pasquotank and Perquimans rivers			275	56			41,579	7,898
Chesapeake Bay							1,638,844	167,929
James River and tributaries					1,800	130	495,762	51,247
York River and tributaries					590	64	546,548	50,361
Mobjack Bay							140,777	13,874
Rappahannock River					1,073	83	417,789	35,371
Potomac River			600	150			684,063	63,608
Nanticoke River and tributaries	9,337	$795					216,308	20,668
Choptank River and tributaries	598	56					338,420	35,810
Susquehanna River			12,100	2,113	2,003	259	140,087	20,153
Miscellaneous rivers	3,897	510	25,412	3,570			249,021	31,736
Delaware Bay							1,103,821	104,761
Delaware River					5,400	540	2,778,803	300,598
Miscellaneous rivers			2,300	445			134,838	21,147
Ocean shore of New Jersey	1,500	375					16,240	3,518
New York Bay	57,308	8,889					216,425	30,941
Hudson River	800	123					588,898	83,237
Great South Bay and Gardiner Bay							4,755	1,092
Long Island Sound							9,427	2,399
Connecticut River							51,690	9,508
Miscellaneous rivers					482	115	13,202	3,324
Ocean shore of Rhode Island							1,051	287
Narragansett Bay and tributaries					1,060	306	15,836	4,237
Buzzards Bay and Vineyard Sound							3,385	834
Cape Cod and Massachusetts bays							33,082	1,468
Casco Bay							64,490	3,580
Kennebec River and tributaries							290,122	26,257
Penobscot and other Maine rivers							12,126	941
Total	73,440	10,748	123,803	25,776	15,172	2,115	13,053,429	1,651,443

It has been customary heretofore to report the yield of shad in pounds, but various causes have combined to render it advisable to report the yield according to the number. It is hoped that this sacrifice of custom will not involve any loss of clearness. The weight of these fish ranges from 1 to 10 pounds, averaging about $3\frac{3}{4}$ pounds. For convenience of those who prefer reckoning shad according to their weight, the following summary is presented, showing, by States and by sexes, the number and weight of the shad yield in 1896.

Statement of the number, weight, and value of roe and buck shad caught on the Atlantic coast of the United States in 1896.

States.	Roe.			Buck.			Total.		
	No.	Pounds.	Value.	No.	Pounds.	Value.	No.	Pounds.	Value.
Florida	171, 752	677, 954	$26, 417	288, 462	620, 651	$36, 172	460, 214	1, 298, 605	$62, 589
Georgia	62, 604	294, 641	23, 953	81, 370	241, 986	25, 336	143, 974	536, 627	49, 289
South Carolina	70, 376	405, 471	19, 160	76, 251	266, 042	14, 276	146, 627	671, 513	33, 436
North Carolina	942, 843	4, 804, 508	246, 676	1, 153, 961	4, 038, 200	170, 567	2, 096, 804	8, 842, 708	417, 243
Virginia	1, 574, 274	6, 700, 890	198, 758	1, 629, 229	4, 469, 629	108, 297	3, 203, 503	11, 170, 519	307, 055
Maryland	717, 523	3, 295, 102	101, 831	823, 527	2, 246, 397	64, 720	1, 541, 050	5, 541, 499	166, 551
Delaware	282, 598	1, 442, 318	51, 194	185, 746	550, 976	18, 066	468, 344	1, 993, 294	69, 260
Pennsylvania	372, 199	1, 839, 602	57, 019	249, 040	661, 541	22, 426	621, 239	2, 501, 143	79, 445
New Jersey	2, 132, 031	10, 281, 510	268, 454	1, 206, 449	3, 628, 316	71, 602	3, 338, 480	13, 909, 826	340, 056
New York	324, 713	1, 563, 783	55, 354	218, 101	636, 763	19, 479	542, 814	2, 200, 546	74, 833
Connecticut	33, 495	150, 811	8, 623	36, 793	110, 379	5, 459	70, 288	261, 190	14, 082
Rhode Island	7, 921	35, 646	2, 477	5, 611	17, 115	1, 113	13, 532	52, 761	3, 590
Massachusetts	19, 035	64, 718	1, 988	20, 787	49, 434	1, 248	39, 822	114, 152	3, 236
Maine	172, 920	820, 140	19, 448	193, 818	584, 337	11, 330	366, 738	1, 404, 477	39, 778
Total	6, 884, 284	32, 377, 094	1, 081, 352	6, 169, 145	18, 121, 766	570, 091	13, 053, 429	50, 498, 860	1, 651, 443

The values set forth in the aforegoing table fail in doing justice to the importance of this fishery, those figures representing merely the net price which the fishermen received, this amount being greatly increased by the time they reached the consumer. Thus the value of the 456,281 shad taken on the St. Johns River in Florida is reported at $61,924, an average of $13.57 per 100 fish. The cost of packing and expressage to New York City, for instance, approximates $10 per 100. Then comes the expenses and profit of the wholesale dealer or commission merchant and that of the retailer, which may approximate $5 and $12, respectively, per 100. This makes the cost of the fish to the consumer about $40.57 per 100. Estimated at this rate, the yield on the St. Johns in 1896 was worth $185,113, instead of the reported value, $61,924. The average value to the fishermen for the entire yield of the Atlantic coast was $12.64 per 100 fish, while the consumers probably paid $25 per 100. Assuming this basis as correct, the consumers paid $3,263,357 for the 13,053,429 shad caught in 1896.

The prices in 1896 were unusually small, and this limited the total catch considerably. During April and May the markets were glutted, and prices fell so low that many fishermen ceased operations.

The following table shows the wholesale prices of shad prevailing in New York and Philadelphia on Friday of each week during the first six months of 1896:

Week ending—	New York.		Philadelphia.		Week ending—	New York.		Philadelphia.	
	Roe.	Buck.	Roe.	Buck.		Roe.	Buck.	Roe.	Buck.
Jan. 3	$1.10	$0.50	$1.00	$0.50	Apr. 3	$0.28	$0.15	$0.25	$0.14
10	1.00	.40	1.00	.50	10	.23	.11	.25	.13
17	.90	.50	1.00	.45	17	.25	.15	.15	.07
24	.75	.37	.88	.47	24	.28	.13	.18	.08
31	.88	.30	.95	.50	May 1	.20	.11	.16	.08
Feb. 7	.75	.23	.75	.32	8	.23	.11	.20	.10
14	.75	.30	.80	.35	15	.23	.11	.14	.07
21	.80	.43	.75	.38	22	.20	.09	.18	.09
28	.80	.38	.90	.42	29	.25	.11	.20	.10
Mar. 6	.45	.23	.70	.35	June 5	.22	.10	.20	.10
13	.50	.23	.40	.20	12	.25	.12	.25	.12
20	.25	.14	.40	.20	19	.22	.10		
27	.35	.17	.35	.18	26	.20	.09		

COMPARISON WITH PREVIOUS YEARS.

In considering the comparative abundance of shad it is not safe to be guided by the results of the fisheries in a single locality or even in an individual river basin. The catch in each locality fluctuates under local conditions, and it is only by comparing the returns for a large area of the coast that it can be determined whether there has been an actual increase or decrease.

The season of 1880 is the earliest one for which we have accurate or even fairly reliable data relative to the yield of shad along the entire Atlantic coast or even a considerable portion of that coast. The adverse agencies tending to deplete the species had then reduced the yield to a very low point and the effect of artificial propagation had not become generally apparent. During that year the total yield of shad on the Atlantic coast approximated 5,162,315 in number, worth $995,465. The use of improved apparatus of capture and the more vigorous prosecution of the fisheries has resulted in a considerable increase in the aggregate yield since that season. The yield in 1888 was reported at 10,181,605, for which the fishermen received $1,665,176; in 1892 it was 11,094,565, valued at $1,879,688, and in 1896 it numbered 13,053,429, worth $1,651,443 at first hands.

While the yield in 1896 was by far the largest of any of the four years above noted, yet that season was scarcely representative of the last three or four years. Not only were shad less abundant than usual, but the prices were so low that many fisheries were abandoned before the season was at an end. However, in the rivers of Florida and Georgia, in Delaware River, and Connecticut River the catch in 1896 was the largest for many years. From Savannah River to the Chesapeake Bay, inclusive, the yield in 1895 and in 1897 was far in excess of that in 1896.

The following summary shows by States the yield of shad in 1880, 1888, and 1896. The returns for 1880 and 1888 were published in pounds, and in reducing them to number the average weight has been assumed to be 3½ pounds each.

State.	1880.		1888.		1896.	
	Number.	Value.	Number.	Value.	Number.	Value.
Florida	71,914	$20,136	413,714	$89,630	460,214	$62,589
Georgia	72,000	17,941	75,200	19,000	143,974	49,289
South Carolina	59,314	12,432	123,657	27,050	146,627	33,436
North Carolina	920,360	329,569	1,608,774	292,409	2,096,804	417,243
Virginia	906,272	134,496	2,316,235	376,944	3,203,503	307,055
Maryland	1,074,121	140,326	1,598,781	218,230	1,541,050	166,551
Delaware	300,000	52,500	396,919	51,999	468,344	69,260
Pennsylvania	159,885	27,980	396,340	76,942	621,239	79,445
New Jersey	214,285	35,000	1,863,842	307,411	3,338,480	340,056
New York	781,028	136,680	984,468	150,882	542,814	74,833
Connecticut	376,581	65,902	104,553	23,786	70,288	14,082
Rhode Island	13,743	2,405	4,971	1,213	13,532	3,590
Massachusetts	47,007	8,226	51,316	5,312	39,822	3,236
Maine	165,805	11,876	242,835	24,368	366,738	30,778
Total	5,162,315	995,465	10,181,605	1,665,176	13,053,429	1,651,443

It appears that since 1880 there has been an increase in the yield in every State south of New York, and from that point northward there has been a decrease in each State except Maine. The greatest increase has occurred in New Jersey, the yield of shad in that State in 1880 numbering 214,285, which was increased in 1888 to 1,863,842, and in 1896 to 3,338,480. Virginia ranks next with an increase from 906,272 in 1880, to 2,096,804 in 1896. The largest decrease has occurred in Connecticut, where the catch in 1880 numbered 376,581, and in 1896 only 70,288.

The yield for the entire coast shows an increase of 97 per cent in the eight years from 1880 to 1888, and from 1888 to 1896 the increase was 28 per cent. The value of the shad, however, does not show so great an increase. Indeed, comparing the returns for 1888 with those of 1896, we find that while the total number of shad increased 2,871,824, the value decreased $13,733. The average price received by the fishermen for shad in 1880 was $19.28 per hundred; in 1888, $16.35, and in 1896, $12.65 per hundred.

In considering the recent yield of shad with that prior to 1880, few data exist on which to base satisfactory conclusions. It is well to guard against placing too great confidence in estimates as to the early abundance of these fish. In the report of the Maine Fish Commission for 1867, the yield of shad on the Penobscot during the preceding season was estimated at 2,500,000 in number, but a careful survey of the fisheries of that river during the following season, made by the same commissioners, showed that the number of shad caught approximated only 5,000. If this correction had not been made, the former number would doubtless have prevailed as the basis for comparisons of the former and present abundance of shad in Penobscot River. In the Gazetteer of Virginia, published in 1835, is an account of the fishery resources of Potomac River, which includes the remarkable statement that in a good season of six weeks the catch of shad on that river numbered 22,500,000, while the alewives caught annually reached the remarkable number of 750,000,000. And this estimate has been used by many writers as a basis for lengthy discussions of the decrease of shad in the Potomac.

True, there are numerous records, kept with great accuracy, showing the yield of shad at individual fisheries, and even for entire river basins, for periods of 20, 40, and even 60 or more years prior to 1880, but they can not be taken as a basis for determining the abundance or comparative yield of this species all along the coast. Great changes have occurred in manner of prosecuting the fisheries and even in the fishing-grounds during the past half century. Formerly the great bulk of shad were caught by means of seines, while at present the large catches made by drift nets, stake nets, pound nets, etc., leave a comparatively small number to be caught in the original form of apparatus. Also the large increase in the amount of apparatus employed results in a much smaller average catch for each individual apparatus. If only 20 seines or pound

nets are used in a certain water-course, it is to be expected that the average catch per net will be greater than if that number be increased to 100. And while probably in many of the water areas along the coast the average catch of shad per net is less at present than formerly, yet it is equally probable that the present aggregate yield of shad is much greater than ever before.

An account of the comparative abundance of shad in each water area will be found in the latter half of this report, containing a discussion of the fisheries of each separate locality.

We must not overlook the great length of water-courses formerly abounding in shad from which these fish are now excluded by means of dams and other obstructions. But to offset this there has been a great extension of the fisheries into water areas in which no shad whatever were caught half a century ago. Formerly the great bulk of the yield was obtained from the middle and upper sections of the rivers, while at present nearly all the catch is obtained in the lower section and in the salt water of the estuaries. The extension of the fisheries into the estuaries is of recent origin, dating only from the middle of the present century, and their development has been principally during the past twenty years. It requires large and costly apparatus to prosecute the fisheries there, and forms suitable have come into use only quite recently.

With the exception of drift nets in Delaware Bay, New York Bay, and one or two less important places, and the mackerel purse seines, which take a few shad on the New England coast, pound nets and stake nets are the only forms of apparatus employed in catching shad in salt water.

Over 90 per cent of the shad caught in salt water of the Chesapeake region are taken in pound nets, yet the use of that apparatus there dates only from 1865, and not until 1875 were they extensively employed. Stake nets and pound nets, which catch practically all the shad taken in the salt water of North Carolina, have been used in that region only since 1865. It thus appears that, while the up-river fisheries are decreasing, a very large area is being added to the fishing-grounds. At present nearly half of the total shad yield on the Atlantic seaboard is obtained in salt water, and those fisheries are becoming more extensive each year.

The following summary shows, approximately and in comparative form for each water area, the number and value of the shad caught in 1896 and the number and percentage of those taken in salt water. The line of demarcation between the salt and fresh water of the estuaries being indefinite and variable, this table is only approximately correct for certain regions, but the percentage of error is too small to materially affect the general result.

Table showing the number and value of shad taken in 1896, and the number and percentage of those taken in salt water.

Water areas.	Total yield.		Yield in salt water.	
	Number.	Value.	Number.	Per cent.
St. Johns River	456,281	$61,924		
St. Marys River	10,193	1,754		
Satilla River	1,500	240		
Altamaha River	29,377	10,096		
Ogeechee River	55,425	19,514		
Savannah River	54,406	19,236		
Combahee River	3,090	622		
Ashepoo River	6,880	1,381		
Edisto River	28,273	5,843		
Cooper River	396	126		
Santee River	7,309	1,547		
Winyah Bay and tributaries	97,685	23,031		
Cape Fear River	75,315	18,964		
Pamlico Sound	448,089	109,727	448,089	100
Neuse River	207,052	39,067	82,238	39.72
Pamlico-Tar River	67,082	13,316	18,873	28.13
Croatan and Roanoke sounds	169,541	33,201	169,541	100
Albemarle Sound	735,192	140,159	186,290	25.34
Roanoke River	169,409	20,489		
Chowan River	183,545	34,422		
Pasquotank and Perquimans rivers	41,579	7,898		
Chesapeake Bay	1,638,844	167,929	1,428,327	87.15
James River and tributaries	495,762	51,247	100,379	20.25
York River and tributaries	546,548	50,361	182,375	33.37
Mobjack Bay	140,777	13,874	140,777	100
Rappahannock River	417,789	35,371	194,067	46.45
Potomac River	684,063	63,608	210,480	30.76
Nanticoke River and tributaries	216,308	20,668	42,405	19.60
Choptank River and tributaries	338,420	35,810	136,972	40.47
Susquehanna River	140,087	20,153		
Miscellaneous	249,021	31,736	29,851	11.98
Delaware Bay	1,103,821	104,761	1,103,821	100
Delaware River	2,778,803	300,598	976,669	35.13
Miscellaneous rivers	134,838	21,147		
Ocean shore of New Jersey	16,240	3,518	13,765	84.75
New York Bay	216,425	30,941	213,925	98.84
Hudson River	588,898	83,237		
Great South Bay and Gardiner Bay	4,755	1,092	4,755	100
Long Island Sound	9,427	2,399	9,427	100
Connecticut River	51,690	9,508		
Miscellaneous rivers	13,202	3,324		
Ocean shore of Rhode Island	1,051	287	1,051	100
Narragansett Bay and tributaries	15,836	4,237	2,163	13.66
Buzzards Bay and Vineyard Sound	3,385	834	3,385	100
Cape Cod and Massachusetts bays	33,082	1,468	33,082	100
Casco Bay	64,490	3,580	64,490	100
Kennebec River and tributaries	290,122	26,257	55,987	19.30
Penobscot and other Maine rivers	12,126	6,941	6,000	49.48
Total	13,053,429	1,651,443	5,859,184	45.26

The preceding summary shows that in 1896 45 per cent of the total shad yield was caught in regions which half a century ago yielded none whatever, this in some measure compensating for the 3,700 miles of river course from which they are now wholly excluded and the lengths from which the exclusion is partial. It thus appears that the principal change in the fisheries during the past fifty years has been one of location rather than extent of the total yield, the great increase in the estuaries compensating for the decrease in the headwaters. This change in the fishing-grounds results in a large portion of the fish being taken before they reach the spawning areas in fresh water, thereby preventing them from adding their quota to future supply almost as effectually as though they were excluded therefrom by means of dams or otherwise. But the same result is accomplished when the fish are caught after reaching those areas, and before spawning. Furthermore,

moving the seines and other apparatus of capture over the spawning-grounds disturbs and drives away the fish from those areas and destroys many of the eggs and young shad already there.

The construction of dams has excluded shad from a large portion of the spawning-grounds, notwithstanding the erection of fishways in those obstructions. Sawdust, chemicals, and other refuse, and agricultural operations, have greatly impaired the utility of the spawning areas even now available, and the extensive fisheries have very largely decreased the number of shad reaching those areas. These adverse agencies have reduced natural reproduction to almost an insignificant factor in keeping up a supply ample to maintain the present fisheries, rendering artificial propagation essential to their prosperity. They so affected the abundance of shad that during the Seventies the returns of the fisheries reached a minimum. Then the results of artificial propagation began to appear, not only maintaining an equilibrium, but greatly increasing the abundance. While the increased yield was preceded by an increase in the quantity of apparatus used, yet it was made possible by the greater abundance of shad due to artificial propagation. Comparing 1880 with 1896, it is observed that the increase in the yield numbered 7,891,114. At 25 cents each (the average paid by consumers), this represents an increase of $1,972,778 in the value, over sixty times the expenditure for shad propagation, a result probably unsurpassed in any other line of fish-culture.

The general condition of the shad fisheries along the entire coast having been noted we now proceed to a description of the fisheries of each individual water area, those areas being grouped according to States, beginning with the southernmost and proceeding northward.

THE SHAD FISHERIES OF FLORIDA.

The extent by water areas of each branch of the shad fisheries of Florida in 1896 is presented in the following series of three tables, showing (1) the number of persons employed, (2) the boats, apparatus, etc., used, and (3) the number and value of shad taken. There are but two rivers in this State which support commercial shad fisheries, viz, the St. Johns and the St. Marys.

Statement, by water areas, of the number of persons employed in each branch of the shad fisheries of Florida in 1896.

Waters.	Fishermen.				Shoresmen.	Transporters.	Total.
	Drift-net.	Set-net.	Seine.	Total.			
St. Johns River:							
From sea to Jacksonville	292			292	16	2	310
Palatka section	38			38	7		45
Upper St. Johns	7		110	117	8	3	128
St. Marys River	20	20		40			40
Total	357	20	110	487	31	5	523

Statement, by water areas, of the boats, apparatus, etc., employed in the shad fisheries of Florida in 1896.

Waters.	Boats.		Drift nets			Set nets.		
	No.	Value.	No.	Length.	Value.	No.	Length.	Value.
St. Johns River:				*Yards.*			*Yards.*	
From sea to Jacksonville	146	$7,720	146	83,500	$15,625			
Palatka section	21	394	22	5,250	1,260			
Upper St. Johns	54	1,060	3	1,400	165			
St. Marys River	30	210	20	1,400	300	10	850	$200
Total	251	9,384	191	91,550	17,350	10	850	200

Waters.	Seines.			Shore property.	Total investment.
	No.	Length.	Value.		
St. Johns River:		*Yards.*			
From sea to Jacksonville				$3,614	$26,959
Palatka section				400	2,054
Upper St. Johns	24	7,150	$2,175	335	3,735
St. Marys River					710
Total	24	7,150	2,175	4,349	33,458

Statement by apparatus of the yield of shad in the waters of Florida in 1896.

Waters.	Drift nets.		Set nets.		Seines.		Total.	
	No.	Value.	No.	Value.	No.	Value.	No.	Value.
St Johns River:								
From sea to Jacksonville	291,116	$47,720					291,116	$47,720
Palatka section	37,300	5,222					37,300	5,222
Upper St. Johns	2,617	355			125,248	$8,627	127,865	8,982
St. Marys River	2,244	380	1,689	$285			3,933	665
Total	333,277	53,677	1,689	285	125,248	8,627	460,214	62,589

ST. JOHNS RIVER.

St. Johns River has its sources in the swamps and marshes of eastern Florida, flows nearly parallel with the coast a distance of 375 miles, and enters the ocean near the northeastern corner of the State. It is navigable to a point about 300 miles from the mouth, and steamers ascend regularly as far as Sanford, 230 miles by the river course from the sea. It is very broad, the width in the lower 100 miles being from 1 to 5 miles, and for two-thirds of its length it is over a mile wide, often expanding into spacious lakes. There are no permanent obstructions to the passage of fish, and shad ascend nearly to the sources of the river. The St. Johns differs from all other streams on the Atlantic coast of the United States in that its sources are in warmer latitudes than its entrance into the ocean. All the other streams run south and east, and the water flowing therein is much cooler during the winter and spring than the sea water. The effect of this peculiar condition is thus described by the late Marshall McDonald:

In the St. Johns River, Florida, shad appear several months before the spawning time, and although this is not largely in advance of the same season in rivers as far north as certain tributaries of the Chesapeake, yet by reason of their early presence in the St. Johns the fisheries are prosecuted during the entire winter. They do not enter the river at this time for the purpose of spawning. By reference to tables giving

the temperature of the St. Johns River at Jacksonville, it is seen that the temperature of the water gradually descends, reaching 60° F. at Jacksonville about the last of November. This date is coincident with the first appearance of shad in the St. Johns. * * * In all other streams on the Atlantic coast the fish appear to wait until the temperature of the river has risen above that of the salt-water area into which the river empties before they ascend in the spring. The migration of shad into the St. Johns River is clearly not for the immediate purpose of spawning, as that operation is not performed for months, but in order that they may keep within the limit of the hydro-isothermal area appropriate to them. We must suppose that the temperature of the ocean waters, on the continental plateau outside the coast line, is higher than 60° F., and although uncongenial to the fish, yet they must necessarily remain in that temperature until the waters of the St. Johns, cooling as the winter advances, have fallen below the temperature of the outside waters. As soon, therefore, as water of a lower temperature than that in which they are commingles with the ocean water it serves as an incentive—as it were, the signal—for their migration into the estuary of the St. Johns.—(Natural History of Aquatic Animals, pp. 599–602.)

Shad fishing on the St. Johns is of recent origin. Indeed, it is claimed by some persons that shad have run up this river during the last forty years only, but this is doubtless erroneous, the absence of extensive fisheries before the Sixties being due to inadequate shipping facilities and insufficient local enterprise. Drift nets were introduced here about 1860, and their use increased quite rapidly, most of them being operated by fishermen from Connecticut and New Jersey. The war interrupted all fishing except for local use, but at the close of hostilities the operation of drift nets was renewed and greatly increased. It is reported that, in 1873, 94,000 shad were caught with 30 nets operated from New Berlin, about 10 miles from the mouth of the river, and that in 1876, when shad were unusually abundant, the average catch at New Berlin was 5,000 per net. At Palatka, 100 miles from the mouth of the river, drift nets were first used in 1872, and 7 nets in 1876 caught 66,000 shad, the largest yield in any one net numbering 11,000.

In a letter from Jacksonville, dated in January, 1874, Dr. Charles Koch says:

From the bar at the mouth of the St. Johns River up to Palatka 75 to 80 nets are fished during the shad season. These nets are 200 yards long and 10 feet deep and are set in from 10 to 12 feet of water. In 1873 the product of the shad fisheries amounted to 250,000 shipped or consumed. The average price at Jacksonville was 15 cents apiece.

Mr. R. E. Earll estimated that in 1877–78 there were 80 drift nets on the river and that the average catch was 2,500 each, making a total of 200,000 shad for that season. He further states that the yield for the previous season approximated 280,000, and for 1875–76 the yield was about 160,000 or less. The Tenth Census reports the yield in 1879–80 at 251,700 pounds, but it does not appear what basis has been used in reducing the number to pounds. No mention is made in those estimates of the use of seines.

The yield of shad on the St. Johns in 1890 was the largest for many years, numbering 872,074. During the four years following the catch gradually decreased; but in 1895 it was somewhat better, and this

increase was continued in 1896. In the last-named year the entire yield was 170,252 roes and 286,029 bucks, a total of 456,281, of which 331,033 were taken in drift nets and 125,248 in seines. Comparing the number of fishermen in 1890 and 1896, it appears that the yield of 872,074 shad in the former year was obtained by 442 men, whereas the 456,281 shad in 1896 were secured by 447 fishermen, an increase of 1 per cent in the number of fishermen and a decrease of nearly 50 per cent in the number of shad secured. The catch in 1890 was made with 191 gill nets and 10 seines, while in 1896 there were used 171 gill nets and 24 seines.

From the foregoing it appears that the yield of shad on the St. Johns during the years noted has been as follows:

Year.	No. of shad.	Year.	No. of shad.
1864	None reported.	1878	200,000
1873	250,000	1880	71,914
1876	160,000	1890	872,074
1877	280,000	1896	456,281

Shad enter this river late in November and remain till the following May or June. The legal season extends from December 1 to the end of the following March, with close time "between sundown on Saturday afternoon and sunrise on Monday morning of each week." Actual fishing operations begin at the opening of the legal season, fully a month before shad are caught in any other water on the coast, and end about the second or third week of March. According to Dr. Goode:

> The spawning time is apparently from the middle of March to the latter part of April. * * * The fishermen say that the shad spawn at the very head of the river, but I have no doubt that many deposit their eggs on convenient grounds nearer the sea. The fishermen also have a notion that shad that have well ascended the river never return, for they say they have never known a spent fish. This they account for by the theory that they are devoured by the alligators and catfish, the shad being weak and helpless after spawning.

An interdiction exists against the use in this State of "any gill nets for the capture of shad with a mesh less than 5 inches from knot to knot measured lengthwise, that is to say, a mesh when brought to a square, the sides of which are not less than 2½ inches" or any seine with a mesh less than 3 inches.

There are three distinct geographical sections in the shad fisheries of the St. Johns, viz, (1) from the mouth of the river to Jacksonville; (2) the Palatka region from Bridgeport to Welaka, and (3) from Lake George to Lake Harney. Of the 456,281 shad taken on the river in 1896, 291,116, valued locally at $47,720, were caught in the first section; 37,300, worth $5,222, in the second, and 127,865, worth $8,982, in the third section. The fisheries of each of these regions will be described in succession.

From the sea to Jacksonville.—In the lower section of the river, from the sea to Jacksonville, a distance of 28 miles, situated wholly within Duval County, the drift net is the only form of apparatus used in

taking shad. These range in length from 500 to 600 yards, averaging about 575 yards, with 5-inch mesh and from 40 to 50 meshes deep. They are heavily leaded, the leads weighing 2 ounces each and placed 2 or 3 feet apart. The average cost of the nets approximates $125, and 2 men are required for each. They are set directly across the current, one end being buoyed and the other attached to the boat, and are allowed to drift with the current. They are operated during both ebb and flood tides, but usually the flood tides yield larger returns.

The number of drift nets operated in this section in 1896 was 146, aggregating 83,500 yards in length and $15,625 in value, and requiring the services of 292 men. Comparatively few of these men are natives of Florida, many of them coming from Connecticut and New Jersey and residing in Florida only during the shad season. The catch, which was unusually large, consisted of 125,346 roe shad and 165,770 bucks, valued locally at $17,720. Nearly all of these fish were shipped to New York City and other distant markets.

From Jacksonville to Bridgeport, a distance of 46 miles, the river is from 2 to 5 miles in width and quite sluggish, so as to preclude the use of drift nets, and no fisheries are operated.

The Palatka section.—The second division of St. Johns River extends from Bridgeport to Welaka, a distance of 35 miles, located wholly within Putnam County. Drift nets exclusively are used in this stretch of the river, and the fishery is centered at Palatka, a town of 3,000 inhabitants. These nets are much shorter than those used below Jacksonville, averaging in length about 240 yards each, with a scant 5-inch mesh, and costing about $60. The number used in 1896 was 22, each net requiring the services of one boat and usually of two men, although in a few instances a single man operated one net. The water was unusually low, retarding the ascent of fish beyond Welaka, and the yield in this portion of the river was the largest since 1890, the total catch in the 22 drift nets numbering 9,550 roe shad and 27,750 bucks, valued locally at $5,222.

The Palatka fishermen complain considerably of the injury caused by the presence of a species of water hyacinth (*Piaropus crassipes*) in the river. This plant was introduced into the St. Johns in 1890 from a small pond at Edgewater, near Palatka. It becoming desirable to clean the pond, the plants were thrown into the river, where they flourished luxuriantly, producing masses of flowers and adding an attractive feature to the river scenery. It does not become fixed to the soil, and its movements are governed by the wind and current. During the past three or four years it has increased so abundantly and its range has been so extended as to seriously impede the operations of the fishermen, being distributed quite generally from Bridgeport to Lake George and existing to some extent as far down the river as Jacksonville. Several of the drift-net reaches in the vicinity of Palatka have been seriously injured by the plant, which gets entangled in the nets and causes much trouble and loss of twine. Occasionally, under favorable

conditions of wind and tide, the fishermen of certain reaches are prevented from operating their nets for several days at a time by reason of the mass of vegetation covering the water. Should the plant spread during the next few years as it has during the past six, drift-net fishing in the Palatka section will necessarily be abandoned.

From Lake George to Lake Harney.—This portion of the river, known as the Upper St. Johns, consists of a series of connected lakes, the most important being Lakes George, Dexter, Monroe, and Harney. Sanford, a town of 3,000 inhabitants, on the shore of Lake Monroe, is the center of the shad fisheries. This town is practically the head of navigation on the river, daily steamers connecting it with Jacksonville, over 200 miles distant.

Seines are the principal apparatus used in this section, the only other apparatus employed being a very few drift nets. Of the 127,865 shad taken in 1896, 125,248 were obtained in seines and 2,617 by drift nets. An interdiction exists against the use of seines in the lakes forming part of the St. Johns; consequently most of the seine fishing is confined to the channels connecting the lakes. Drift nets can, of course, be used only in the channels, and the extent of the seine fishery there restricts the use of drift nets.

There were only three drift nets reported from the Upper St. Johns in 1896. Two of these were each 600 yards in length and the third was 200 yards long, the mesh in all being 5-inch. The catch numbered 1,445 roe shad and 1,172 bucks, valued locally at $355.

The seines range in length from 200 to 700 yards, 50 to 100 meshes deep, with 3 or 4 inch mesh. They cost from $60 to $300, and require from 4 to 10 men each, according to the length of the seine and the strength of the current. The 24 seines used in 1896 aggregated 7,150 yards in length and $2,175 in value, and required the services of 110 fishermen and 50 small boats, worth $1,000, in addition to which 1 steam launch, worth $2,000, was used in transporting the fish to Sanford. The catch numbered 33,911 roe shad and 91,337 bucks, valued locally at $8,627. Among the bucks are included 53,807 "skips," which average in weight about 1 pound each. In the early part of the season shad are sold to the Palatka shippers as high as 50 cents each, but the price falls rapidly, and when the season is at its height the price is frequently less than $7.50 per 100.

ST. MARYS RIVER.

St. Marys River has its source in the Okefenokee Swamp, whence it forms the boundary line between Florida and Georgia for a distance of 175 miles to its entrance into the Atlantic. It is narrow, but deep and tidal nearly the whole length, and is navigable for steamboats as far as Traders Hill, 45 miles from the ocean. There are several small steamer landings on the river, but the only settlement of considerable size is St. Marys, a town of 700 inhabitants on the Georgia side of the river near the mouth. Owing to its proximity to the St. Johns, and the

greater abundance of fish in that stream, as well as to the meager shipping facilities on the St. Marys, very little attention has been given to catching shad in the latter river. The fisheries are confined to the use of a few drift nets and stake nets by men living between Crandall and Kings Ferry, most of the catch being landed at Oakwell, Ga., and Kings Ferry, Fla., whence it is carted to the nearest railroad station and shipped to distant markets. Some few shad are also taken for home use by means of bow nets, but this fishery is of little consequence and no data are at hand to show its actual extent. Seine fishing is scarcely practicable on the St. Marys, as the stream is so narrow and the tidal current so strong that seines could be hauled only during slack water.

The number of men employed in the shad fisheries of the St. Marys in 1896 was 110, 40 of whom lived on the Florida side of the river and 70 on the Georgia side. They commenced fishing about the 1st of January and continued until some time in April, 80 using drift nets and 30 using set nets. The drift nets numbered 80, with an aggregate length of 5,600 yards and valuation of $1,200. On account of the numerous snags and the narrowness of the river, the longest nets used are only 90 yards, and some are only 40 yards in length. The mesh is generally 5 inches and the depth about 14 feet. The stake nets numbered 15, with a length of 1,275 yards and valued at $300. By the drift nets 3,363 roe shad and 4,246 bucks, worth $1,313, were taken, while the set nets caught 1,062 roe shad and 1,522 bucks, valued locally at $441, making a total of 10,193 shad, worth $1,754, caught on St. Marys River, of which 3,933 were taken by men living on the Florida side and 6,260 by residents of Georgia.

THE SHAD FISHERIES OF GEORGIA.

Although requiring a greater number of fishermen the shad fisheries of Georgia are not so extensive as those of Florida as regards the value of boats, apparatus, etc., and the quantity and value of shad taken, as appears from the following series of tables showing the extent of the fisheries of Georgia by water-courses:

Statement, by water areas, of the number of persons employed in each branch of the shad fisheries of Georgia in 1896.

Waters.	Fishermen.				Total, exclusive of duplication.
	Drift-net.	Set-gill-net.	Bow-net.	Fall-trap.	
St. Marys River	60	10			70
Satilla River	7				7
Altamaha River	162	128	30		320
Ocmulgee River		14	36		36
Oconee River		50	160		170
Ogeechee River	160				160
Savannah River	115	8		3	125
Total	504	210	226	3	888

Statement, by water areas, of the boats, apparatus, etc., employed in the shad fisheries of Georgia in 1896.

Waters.	Boats.		Drift nets.			Set nets.			Bow nets, etc.		Shore property.	Total.
	No.	Value.	No.	Length.	Value.	No.	Length.	Value.	No.	Value.		
				Yards.			*Yards.*					
St. Marys River	65	$455	60	4,200	$900	5	425	$100	....	......	......	$1,455
Satilla River	6	30	3	450	60	....	......	......	....	......	......	90
Altamaha River	165	955	80	4,000	2,000	60	2,000	900	15	$45	$47	3,947
Ocmulgee River	19	95	....	......	......	8	80	24	18	54	......	173
Oconee River	90	450	....	......	......	50	500	200	80	160	......	810
Ogeechee River	84	3,200	80	10,667	5,000	....	......	......	....	......	1,735	9,935
Savannah River	66	1,838	57	17,677	3,828	25	283	68	*a*26	208	1,035	6,977
Total	495	7,023	280	36,994	11,788	148	3,288	1,292	*a*26 113	208 259	2,817	23,387

a Fall traps.

Statement of the number and value of shad caught by each form of apparatus in the fisheries of Georgia in 1896.

Waters.	Drift nets.		Set nets.		Bow nets.		Total.	
	No.	Value.	No.	Value.	No.	Value.	No.	Value.
St. Marys River	5,365	$933	895	$156	......	......	6,260	$1,089
Satilla River	1,500	240	......	......	......	......	1,500	240
Altamaha River	17,310	5,803	7,010	2,270	710	$229	25,030	8,302
Ocmulgee River	......	......	892	368	610	264	1,502	632
Oconee River	......	......	1,300	530	1,545	632	2,845	1,162
Ogeechee River	55,425	19,514	......	......	......	......	55,425	19,514
Savannah River	51,325	18,318	37	14	*a* 50	18	51,412	18,350
Total	130,925	44,808	10,134	3,338	*a* 50 2,865	18 1,125	143,974	49,289

a Fall traps.

SATILLA RIVER.

The shad fisheries of St. Marys River, between Florida and Georgia, have been described in the chapter on the fisheries of Florida. The most southerly river in Georgia is the Satilla, which rises in Irwin County, flows 200 miles through a level sandy region, and enters the ocean 18 miles north of the outlet of St. Marys River. It is navigable for 100 miles from the mouth, a small steamer plying between the river landings and Brunswick.

The commercial shad fisheries of the Satilla are of very recent origin, dating only from 1894, although prior to that year many shad were taken by the river men for their home use. Between Woodbine, 35 miles from the mouth of the river, and Baily Mills, 30 miles above, 3 drift nets were operated in 1896, each 150 yards long, with 5-inch mesh, and the catch approximated 650 roe shad and 850 bucks, valued locally at $240.

The catch in 1895 was about equal to that of 1896, while the yield in 1894 was only about one-half as much as in 1895 or 1896. Except sufficient for local use, all of the shad taken on this stream are sent by boat to Brunswick, Ga.

ALTAMAHA RIVER.

This river is formed by the junction of the Ocmulgee and Oconee rivers, on the line between Appling and Montgomery counties, and, after flowing a distance of 150 miles, empties into the ocean a few miles below the town of Darien, the river, with its many tributaries, being situated entirely within Georgia. The Altamaha is the most southerly stream flowing into the Atlantic whose sources are above the escarpment line, its two principal tributaries rising in the hills of northern Georgia. The total fall of the river from the junction of its head tributaries to Darien approximates 83 feet, an average of 7.6 inches per mile, this slope being nearly uniform. Its width varies from 150 to 800 feet, averaging about 300. It is navigable for vessels of 5 feet draft from the mouth to the junction of its two principal tributaries.

Although shad are quite abundant in the Altamaha, yet the shipping facilities are so unsatisfactory that the fisheries have never been developed, only enough for local use being obtained. These local fisheries extend from the mouth of the river to the junction of its two principal tributaries, but are most extensive in the vicinity of Darien and Doctor Town. The season is much later in the Altamaha than in the rivers south thereof, since the temperature of the water is generally lower, the Altamaha having its sources in the mountains, whereas the other streams rise in the sand hills and swamps near the coast. The forms of apparatus used are drift nets, set nets, and bow nets, named in the order of their importance as determined by the number of shad taken in 1896. Of 25,030 shad caught during that year, 17,310 were obtained in drift nets, 7,010 in set nets, and the remaining 710 in bow nets.

Drift nets are operated principally in the lower part of the river below Doctor Town, although a few are used above that settlement. Most of these are owned by Darien and Brunswick fishermen. In 1896 there were 162 drift-net fishermen on the river, using 80 nets, with a total length of 4,000 yards and valuation of $2,000, and the catch numbered 7,835 roe shad and 9,475 bucks, valued locally at $5,803.

The set nets on the Altamaha are used between Doctor Town and Seward, near the junction of the two tributary streams. These nets are each from 30 to 35 yards in length, with 5½-inch mesh, cost about $15, and require one boat, worth about $5, and 2 men. The total number of nets used in 1896 was 60, and the number of shad taken by them was 3,335 roes and 3,675 bucks, valued locally at $2,270.

Bow nets or skim nets are used in the upper reaches of the river above Doctor Town. Fifteen of these were operated by 30 men in 1896, the catch of shad numbering 310 roes and 400 bucks, worth $229, making the total yield on the Altamaha River in 1896 11,480 roes and 13,550 bucks, valued locally at $8,302.

Ocmulgee River.—This river is formed by the union of South and Yellow rivers about 20 miles below Covington, and thence flows about 300 miles to its union with the Oconee. The head of navigation was formerly at Macon, but at present navigation by steamboats with a draft

of 5 feet or more is confined to that portion below Hawkinsville, a length of about 150 miles. The descent of the river from Macon to its union with the Oconee is nearly 200 feet. At Macon it crosses the fall line in a shoal several miles in length, and above that city there are numerous shoals but no falls of great height until the extreme upper section of the river is reached. Shad ascend the Ocmulgee as far as Macon, but few are taken above Hawkinsville, and nearly all those caught on the rivers are obtained below Abbeville. The catch in 1896 is reported at 1,502, valued at $632, of which 892, worth $368, were taken in set nets, and 610, worth $264, in bow nets.

Oconee River.—This river rises among the hills of northeastern Georgia, the main stream being formed by the union of North and Middle forks, which unite below the town of Athens, at a height of 500 feet above sea level, whence it flows 280 miles to its union with the Ocmulgee. At present steamboats ascend to the crossing of the Oconee and Western Railroad, a distance of 108 miles; but the stream is navigable as far up as Milledgeville, 180 miles from the mouth, where it crosses the escarpment line at a height of 221 feet above sea level. On the Oconee shad are occasionally seen as far up as Milledgeville, but very few are caught above the town of Dublin, 108 miles above the mouth. Below Dublin they are obtained by means of set nets and bow nets, the reported catch in 1896 by the former being 600 roe shad and 700 bucks, worth $530, and by the latter form of apparatus 620 roe shad and 925 bucks, worth $632, a total of 2,845 shad, valued locally at $1,162.

OGEECHEE RIVER.

This river, the only one of importance between the Altamaha and Savannah, is located entirely in Georgia, rising in Greene County, and, after flowing a distance of 350 miles, empties into the Atlantic 38 miles above the entrance of the Altamaha and 16 miles below the mouth of the Savannah. It is navigable for vessels of 16 feet draft for a distance of 25 miles from the mouth, and 10 miles farther for vessels drawing 5 feet. Nearly the whole of the Ogeechee is located below the escarpment line, and it drains extensive swamps. Consequently it is not subject to sudden freshets, and the temperature of the water is generally much higher for corresponding dates than in the two adjacent streams, the Altamaha and the Savannah, which have their sources in the mountains. At the Shoals of Ogeechee, 200 miles from the ocean, where the river crosses the escarpment line, there is a wooden dam 225 feet long and 8 or 9 feet high, used in connection with a gristmill, and 4 miles above is a second wooden dam 280 feet long and 15 feet high, developing 150 horse-power for running a cotton factory. The foot of these shoals is the uppermost limit of the shad range, and very few pass above Millen, 100 miles from the sea.

The Ogeechee ranks first among the shad streams of Georgia, surpassing even the Savannah in the number and value of shad taken and yielding nearly twice as many as the Altamaha and tributaries. Owing

to the higher temperature of the water, shad run up the Ogeechee somewhat earlier than in case of the Altamaha or Savannah, but later than in the St. Johns, the fishing season beginning about the first week in January and continuing until the end of March. Practically all the commercial fishing is carried on with drift nets in the lower 22 miles of the river, the best fishing being near Harvey's Cut, about 10 miles from the sea. Most of the fishermen are non-residents of the river basin, many coming from Savannah and New England and living in house boats during the shad season. Savannah is the headquarters for the fishermen and the principal market for the catch.

The drift nets used on this river range from 200 to 600 feet in length, with 5 to 5¼ inch mesh, and cost from $40 to $135 each. Occasionally they are operated as set nets, being fastened across the current during a flood tide. The number in use in 1896 was 80, aggregating 10,667 yards in length and $5,000 in value. Eighty fishing boats, worth $2,800, and 4 house boats, worth $400, were used, and the catch numbered 22,225 roe shad and 33,200 bucks, valued locally at $19,514.

Several small set nets and bow nets are operated in the middle sections of the river in taking shad for local consumption, but no data are available with which to show the extent of the product.

SAVANNAH RIVER.

The Savannah has its sources in the mountains of western North Carolina, but the river proper is formed by the union of the Tugaloo and the Seneca rivers at Andersonville, S. C., and for a distance of 325 miles it forms the boundary line between Georgia and South Carolina, emptying into the sea a short distance below the city of Savannah. It is navigable for steamboats as far as Augusta, where it crosses the escarpment line. The difference in elevation at this point and at the city of Savannah is 108 feet and the distance 202 miles, giving a mean slope of 0.53 foot per mile. Between Savannah and Augusta there are no villages or considerable collections of houses, except at Pureysburg, S. C., about 23 miles above Savannah. The river averages about 300 feet in width in the lower 170 miles; thence to Augusta the width ranges from 500 to 900 feet. The bed of the stream is of sand, with coarse gravel and rock in limited quantities.

Seven miles above Augusta, where the river crosses the fall line, there is a large dam, developing one of the most important water-powers in the South. When originally constructed, in 1847, the dam was 5 feet high. In 1875 it was enlarged, the height varying from 6 to 15 feet, averaging 10.63, built of stone on a foundation of rock. It extends diagonally up stream for 1,000 feet, thence 720 feet directly across, and is provided with 4 waste weirs, 3 of them 20 feet wide and the other one 15 feet, which may be closed by needles. The dam is overflooded during freshets, the water sometimes standing 7 or 8 feet above its crest. Between the base of this obstruction and Augusta the river descends by a series of falls or rapids a vertical distance of 45 or

50 feet in 4 miles. Because of its injurious effect on the fisheries, this dam has caused much complaint from the residents of the river basin above Augusta. In 1883 a fishway was constructed in the South Carolina end of the obstruction, but its efficiency has never been apparent.

Shad enter Savannah River about the first week of January, and by January 20 the fishing season is well opened and continues until the middle of April, when shad become scarce and garfish so numerous and destructive to the nets that the fishery is abandoned. The commercial fisheries are prosecuted almost wholly by means of drift nets, the only additional apparatus being a few set nets, fall traps, and cast nets, which are operated mainly for other species of fish. Of the 51,412 shad taken by fishermen from the Georgia side of the river in 1896, 51,325 were caught in drift nets, 37 in set nets, and 50 in fall traps. In addition to the above, residents of South Carolina caught 2,974 shad by drift nets and 20 by cast nets, making a total catch in Savannah River of 54,406 shad, worth $19,236.

The principal fishery is in the lower portion of the river along the Georgia shore, and tributary to the city of Savannah, where there were 50 drift nets operated in 1896. These averaged 350 yards in length and 30 feet in depth, with 5¼-inch mesh, and cost about $75 each, requiring one boat, worth $35, and two men for each net. The catch averaged 1,000 shad to the net, this being greater than in any previous season during the past twenty years. The yield in 1895 was an increase over previous years, but the returns for 1896 were much greater than for 1895. Some fishermen attribute this increase to the building of the Government jetty at the mouth of the river, contending that the jetty breaks the force of the freshets and also, to some extent, prevents the fish from passing by the mouth of the Savannah and on to the streams further north. The channel over the bar has also been deepened considerably, and this may have had some beneficial effect. However, it should be noted that in all the streams of Georgia and Florida the catch in 1895 was somewhat larger than during the two or three years immediately preceding, and that the yield in 1896 was also greater than in 1895.

From the northern limit of the Savannah fisheries to the Augusta dam, a distance of 175 miles, the fisheries are prosecuted mainly for local consumption. Very few shad are taken in this length by residents of Georgia, only 23 fishermen being reported for 1896, using 7 drift nets, 25 stake nets, and 26 fall traps, and catching 1,412 shad. From the South Carolina side of the river 13 small drift nets were operated in 1896, yielding 2,974 shad, valued locally at $878. An interdiction exists against fishing with drift nets "from the rising of the sun each Thursday until the rising of the sun on each Monday," but no special effort is made to enforce this regulation.

A few cast nets, of the type common along the southern coast, are used immediately below the Augusta dam. They are operated only in comparatively shallow water where the bottom is free from snags and

bowlders, for if there be rocks or snags the net will "hang," permitting the fish to escape. The use of these nets has considerably decreased; in 1880 12 were reported, whereas in 1896 there were only 3, yielding but 20 shad.

The fall traps used in the rapids immediately below the Augusta dam are made by placing stones in two straight converging lines in the form of a V, but not meeting by 6 or 8 feet, thus constituting breakwaters and preventing the fish from passing except through the opening therein. Within this opening there is constructed a framework of wooden slats with high sides, the up-river end of which rests on the bottom, while the lower end is raised 5 or 6 feet. When the fish come within the influence of the current passing through this apparatus they are forced up on the slatwork and kept there by the strength of the current, the high sides preventing them from flopping over. The space between the slats is about 1 inch wide, permitting small fish to pass through. When the river is low it is difficult for shad to pass these obstructions, but during freshets, which are frequent in the shad season, the traps are submerged and the fish readily pass over them. The scarcity of shad during recent years has resulted in a decrease in the use of this form of apparatus and the profitableness of those now in the river results principally from the capture of catfish. In 1879 there were 110 fall traps, whereas in 1896 only 26 were reported, with an aggregate yield of 50 shad. In 1873 the average catch for each trap was reported at about 10 per day, and it was then stated to be very much less than several years before.

Several valuable seine fisheries formerly existed on the Savannah below Augusta, but none have been operated during the past twenty years. Compared with twenty or more years ago, the yield of shad in the Savannah is small, except in the extreme lower end of the river. A part of this decrease may be ascribed to the large amount of drift-net fishing in the vicinity of Savannah, where the stream is quite narrow and the amount of twine used therein almost completely obstructs the passage of fish. A second cause for the decrease is found in the limitation of the available spawning areas. The quantities of muddy water render the lower length of the stream unfavorable for spawning purposes, and the dam near Augusta prevents utilization of the area above that point, thus limiting the spawning-grounds to a few miles just below the Augusta dam, and within this restricted area the eggs are quickly eaten by the predaceous fish attracted thither.

The Savannah above the Augusta dam.—Above the Augusta dam there are several shoals, but the ascent is slight, being 109 feet in the 51 miles to Petersburg, Ga., an average of 2.1 feet per mile. Omitting Long Shoals Fall, where the river descends 53 feet in 10½ miles, the average for the remaining 40½ miles is less than 18 inches per mile. From Petersburg to Andersonville, S. C., a distance of 55 miles, the current is very swift, the total ascent between the two points being 288 feet. At Trotters Shoals there is a fall of 74.88 feet in 7 miles, and at

several other places falls of over 10 feet per mile occur, with very great velocity of current. In the early part of the present century shad annually migrated in quantities to the headwaters of the Savannah and throughout the Tugaloo, 49 miles in length, and for a distance of 10 miles up the Tallulah, an important tributary of that stream, where their farther progress was barred by Tallulah Falls, 384 miles by the river course from the sea. Since 1846 the dam above Augusta has acted as a barrier to the farther ascent of most of the shad that find their way to that point. The few that pass through the sluices are not sufficiently numerous to warrant commercial fisheries, but they are occasionally taken in apparatus set primarily for other species a distance of 80 or more miles above Augusta.

THE SHAD FISHERIES OF SOUTH CAROLINA.

The following tables show, by water-courses, the extent of each branch of the shad fisheries of South Carolina in 1896. The unusually large number of persons employed for the small number of shad caught is very noticeable, the average yield per man being less than 100 shad:

Statement of the number of men employed in the shad fisheries of South Carolina in 1896.

Waters.	Fishermen.					Total, exclusive of duplication.
	Drift-net.	Stake-net.	Seine.	Bow-net.	Miscellaneous.	
Savannah River	29				*a* 6	35
Combahee River		14				14
Ashepoo River		18		12		29
Edisto River		84	35	159		265
Cooper River		4	4	24		27
Santee River		25		110		132
Winyah Bay and tributaries:						
Winyah Bay and Waccamaw River	518					518
Pee Dee River	4		56	336	*b* 8	404
Lynch River				50		50
Black River				130		130
Sampit Creek				42		42
Total	551	145	95	863	14	1,646

a Cast-net fishermen. *b* Wheel and fall-trap fishermen.

Statement of the apparatus, etc., employed in the shad fisheries of South Carolina in 1896.

Waters.	Boats.		Drift nets.			Stake nets.		
	No.	Value.	No.	Length.	Value.	No.	Length.	Value.
				Yards.			*Yards.*	
Savannah River	17	$115	13	475	$238			
Combahee River	7	280				14	907	$410
Ashepoo River	15	483				17	1,297	590
Edisto River	127	2,490				62	4,253	2,184
Cooper River	5	25				3	200	35
Santee River	75	225				32	1,733	127
Winyah Bay and tributaries:								
Winyah Bay and Waccamaw River	254	9,906	254	85,344	15,240			
Pee Dee River	188	746	4	128	12			
Lynch River	25	75						
Black River	65	195						
Sampit Creek	21	63						
Total	799	14,603	271	85,947	15,490	128	8,390	3,346

Statement of apparatus, etc., employed in the shad fisheries of South Carolina—Cont'd.

Waters.	Seines.			Bow nets.		Miscellaneous.		Shore property.	Total value.
	No.	Length.	Value.	No.	Value.	No.	Value.		
		Yards.							
Savannah River						*a*3	$7	$683	$1,043
Combahee River								50	740
Ashepoo River				6	$15				1,088
Edisto River	12	973	$485	83	231			350	5,740
Cooper River	1	42	70	24	68			100	298
Santee River				55	138			20	510
Winyah Bay and tributaries:									
Winyah Bay and Waccamaw River								1,200	26,346
Pee Dee River	9	800	376	168	422	*b*80	2,178	925	4,659
Lynch River				25	63				138
Black River				65	164				359
Sampit Creek				21	54				117
Total	22	1,635	931	447	1,155		2,185	3,328	41,038

a Cast nets. *b* Wheel and fall traps.

Statement of the yield of shad in each form of apparatus employed in the fisheries of South Carolina in 1896.

Waters.	Drift nets.		Stake nets.		Seines.		Bow nets.		Miscellaneous.		Total.	
	No.	Value.	No.	Val.	No.	Val.	No.	Val.	No.	Val.	No.	Val.
Savannah River	2,974	$878							*a*20	$8	2,994	$886
Combahee River			3,090	$622							3,090	622
Ashepoo River			6,400	1,254			480	$127			6,880	1,381
Edisto River			21,967	4,281	2,634	$640	3,672	922			28,273	5,843
Cooper River			80	25	20	7	296	94			396	126
Santee River			2,065	433			5,244	1,114			7,309	1,547
Winyah Bay and tributaries:												
Winyah Bay and Waccamaw River	80,069	18,454									80,069	18,454
Pee Dee River	190	73			1,608	460	7,759	1,984	*b*694	212	10,251	2,729
Lynch River							820	236			820	236
Black River							5,825	1,439			5,825	1,439
Sampit Creek							720	173			720	173
Total	83,233	19,405	33,602	6,615	4,262	1,107	24,816	6,089	714	220	146,627	33,436

a Cast nets. *b* Wheels and fall traps.

COMBAHEE AND ASHEPOO RIVERS.

The small shad fisheries operated from the South Carolina side of Savannah River have been described in the chapter on the fisheries of Georgia.

Between the Savannah and Edisto rivers there are several small streams, of which only two are entitled to extended notice in connection with the shad fisheries—the Combahee or Salkiehatchie and the Ashepoo. The former rises in Aiken County and is navigable for rafts and light flatboats from the sea to Tobys Creek, near Barnwell, a distance of 110 miles. The second of these streams, the Ashepoo, is situated entirely within Colleton County and has a length of about 60 miles. It was formerly navigable for rafts as far as Walterboro, but the exhaustion of the turpentine forests and the completion of the railroad have reduced navigation to a minimum, resulting in the channel being badly obstructed by brush and driftwood.

Shad ascend Combahee River to Walker and Ashepoo River as far as Walterboro, a distance of 85 and 50 miles, respectively, but the fisheries are centered at the crossings of the Charleston and Savannah Railroad. The shad season in these two streams corresponds with that on the Edisto, running from January 15 to March 31, and the forms of apparatus are similar. The number of set gill nets and stake nets on the Combahee in 1896 was 14, and on the Ashepoo 17 nets were used. The catch by the former was 3,090 shad and by the latter 6,400.

The following shows, for a series of years, the number of shad taken by an average gill-net boat on the Combahee and the Ashepoo rivers, respectively:

Years.	Combahee River.	Ashepoo River.	Years.	Combahee River.	Ashepoo River.
1889	....	1,190	1893	356	978
1890	....	806	1894	552	1,006
1891	538	1,404	1895	462	1,133
1892	368	1,044	1896	531	936

In addition to the foregoing 480 shad are reported as having been taken by means of bow nets in the upper reaches of Ashepoo River, where the narrowness of the channel causes the fish to ascend almost in single file. Some shad are taken by the same form of apparatus in the upper portion of the Combahee, but the difficulties of ascending that stream, at the time of my visit to the lower portion, precludes a statement of the extent of that small fishery. The bow net used on these rivers consists of a frame of light but tough wood, bent and secured in a long oval shape, the longest diameter of which is 10 to 14 feet. Within this frame is loosely fitted a shallow bag of hemp twine, the entire cost of the frame and twine being about $2.50. Two men are required for each net, one of whom propels the boat, while the other, stationed in the bow, manipulates the net.

A few shad are taken on New, Colleton, and Coosawhatchie rivers by the resident planters and timbermen, using bow nets and an occasional gill net, the catch being small and consumed locally. The small extent of the shad fisheries of those streams (the total yield probably not exceeding 1,000 shad) did not warrant a personal investigation.

EDISTO RIVER.

Edisto River, the second in rank among the shad streams of South Carolina, lies wholly within the limits of that State. It is formed by the junction of North and South Forks in the southern part of Orangeburg County, and thence to the ocean it measures 183 miles, although in a straight line this distance is not over 75 miles. The channel is encumbered with drift logs, overhanging trees, and shoals of loose, shifting sand, occasionally varied by hard clay. There are no falls of note on the Edisto, and aside from the trees and shoals there are no obstructions to the ascent of fish from the mouth of the stream to Davis Bridge on the South Fork, and on the North Fork to Jones Bridge, a distance

of 49 miles above Orangeburg and 98 miles from the junction of the two streams. The rafting of timber on this stream, as on many other Southern rivers, exerts a beneficial influence by tending to keep an open passageway for the ascent of fish through the driftwood, overhanging brush, etc.

The commercial shad fisheries on the Edisto extend from near the mouth of the river to Orangeburg on the North Fork, yet they are most extensive near Jacksonboro, at the crossing of the Charleston and Savannah Railroad. They are prosecuted largely by negroes from Charleston, but the number of natives engaged has increased during recent years. The set-gill net is the principal apparatus used, and a few bow nets and seines are employed, especially in the upper reaches of the river, the latter forms of apparatus being used mainly by the natives. The principal gill-net grounds extend from 12 miles below Jacksonboro to 2 miles above that station.

The gill nets are made of No. 40 twine, with 5¼ to 5½ inch mesh, and cost about $35 each. At each end of the net is a rod several feet in length, anchored at one end to keep it upright, and attached by means of a rope bridle to a fixed stake or tree trunk on the shore. The size of the nets varies, but averages about 35 fathoms long "in gear," and 40 meshes deep. They are made, however, to fit the channel of the river, stretching almost from bank to bank and reaching to the bottom, forming a serious impediment to the passage of fish. On account of the clearness of the water fishing can be carried on only at night, thus leaving a free passage for shad during the daytime. The nets are usually not less than 300 yards from each other. In the lower part of the river, where the tide-current is strong, they are put out at three-fourths flood and taken in at one-fourth ebb. The season opens about January 10 and closes the end of March, the greater portion of the catch being made in February. By a State law the time for fishing with gill nets is further restricted to four days of the week, from the rising of the sun each Monday to the setting of the sun each Thursday.

In 1896, 84 men engaged in the gill-net fishery on the lower portion of the Edisto, using 42 boats, worth $2,130, and 62 nets, worth $2,184. The catch amounted to 11,132 bucks and 10,835 roe shad, with a local valuation of $4,281, and in addition thereto 5,258 hickory shad were taken. In 1880 the number of net fishermen was reported at 150 and the catch of shad at 90,000 pounds. In 1890, 48 nets took 30,100 shad. The following record of the catch of one gill-net boat on the Edisto River, from 1885 to 1896, inclusive, is presented as a fair showing of the relative abundance of shad during that period:

Year.	No. of shad.	Year.	No. of shad.
1885	568	1891	1,981
1886	1,180	1892	1,376
1887	1,559	1893	1,095
1888	1,325	1894	1,133
1889	1,702	1895	740
1890	2,036	1896	1,150

In addition to the gill-net fishery, a number of shad are taken on the Edisto by means of small seines and bow nets. In 1896 there was 1 seine operated about 10 miles below Jacksonboro and 8 between that station and Branchville. These seines are 35 to 70 yards long, 3-inch mesh, of No. 9 cotton, and worth on an average from $30 to $45 each. Their catch of shad numbered 2,040, of which 1,080 were bucks. In addition to these, a quantity of hickory shad, striped bass, bream, perch, herring, etc., were taken. Above Branchville 3 seines were used, taking 594 shad in 1896. Hickory shad are caught in considerable numbers at Gibham Ferry and at other points below Branchville, but above that village none are reported.

Bow nets are used by the native planters and woodsmen all along the river from the mouth to the upper limits of Orangeburg County. In 1896 83 were used, by means of which 3,672 shad and 500 hickories were taken, the shad selling at 20 to 40 cents each and the hickories at 5 and 10 cents each. This fishery is carried on generally at night, beginning between 7 and 10 o'clock. Some of the catch is sent to Columbia, but the greater proportion is sold for local use.

CHARLESTON HARBOR AND TRIBUTARIES.

Between the Edisto and Santee rivers are several streams having a common outlet at Charleston, the most important being Cooper, Ashley, and Wando, each of which is small and navigable only for short distances from Charleston. A few shad ascend each of these rivers, but the fisheries are extremely local and limited in extent. Near Monks Corner, at the entrance of the Santee Canal into the west branch of Cooper River, and at several other places on the same river a few shad are taken each year by bow nets, pump nets, gill nets, and seines. In 1896 the total number of shad taken on that stream was 396, of which 216 were caught by pump nets, 80 by bow nets, and the remainder by means of gill nets and seines.

The pump net resembles the bow net somewhat in the principle of its operation, and it is also similar to the contrivances operated from the piers at Chicago. A pole 20 feet long, having suspended from its outer end a pair of cross sticks, to which is fastened a net 10 feet square and with 2½-inch mesh, is "pumped," like a well sweep, on a forked post fixed on the bank of the river.

A few shad are taken in the East Branch of Cooper River and in the lower section of the Wando and Ashley, but the catch is so small as to not warrant an extended investigation in those streams.

SANTEE RIVER AND TRIBUTARIES.

The Santee is formed by the junction of the Congaree and Wateree at a distance from the ocean of 90 miles in a straight line, but, following the sinuosities of the stream, a distance of 184 miles. The river is navigable its entire length, the width at low water varying from 200 to 500 feet, and the fall being less than half a foot per mile. There are

no villages nor considerable collections of houses along the river, the banks being lined with extensive swamps and forests.

On account of the lack of transportation facilities and the limited population in the vicinity, the fishery resources of the Santee have never been developed. The planters and woodsmen along the banks of the stream catch a few shad with bow nets and set gill nets for local use, and near the crossing of the Northeastern Railroad at St. Stephen there is some fishing for distant markets, but the business is inconsiderable. During the year 1896 the shad taken on the river below Wright Bluff, 120 miles from the ocean, numbered 7,309, of which 5,244 were taken by bow nets and 2,065 by gill nets. The small extent of the fisheries did not warrant ascending the river above Wright Bluff, and no reliable account exists of the small catch between that point and the junction of Congaree and Wateree rivers.

Wateree or Catawba.—This river, the principal tributary of the Santee, rises among the Blue Ridge Mountains of North Carolina and follows a winding course of over 400 miles before its union with the Congaree. Shad ascend the Wateree in some numbers as far as Camden, 252 miles from the ocean, and a few are at times taken at the foot of Great Falls, 20 miles farther up, where, in a distance of 8 miles, the fall of the river aggregates 173 feet. It does not appear that shad ever passed above Great Falls in large numbers, if at all. The steep slope of the Wateree above that point, its comparatively small volume of water, and its numerous falls and shoals would seriously impede the progress of shad even if provision were made for their passage above that obstruction.

Congaree River.—The Congaree is formed by the junction of Broad and Saluda rivers, 49 miles above its union with the Wateree. Shad were formerly taken on this river in considerable numbers in the shoals near Columbia, and some ascended each of the main tributaries many miles farther. On Broad River a few stragglers ascended as far as Green River, 141 miles above Columbia and 28 miles above the boundary line between North and South Carolina, or 374 miles from the ocean. The elevation of the mouth of Green River is about 758 feet above sea level, and of the Congaree at Columbia about 135 feet. At present the dam at Columbia appears to be the upper limit of the shad run. No reliable data exists as to the number of shad taken on Wateree and Congaree rivers in 1896, but it was probably less than 2,000.

In 1883 a fishway was constructed over the Columbia dam, consisting of 3½ sections, 36 feet long, with a total rise of 9 feet. It is substantially built and is of the type known as the McDonald Fishway, consisting of two sets of buckets, straight-wooden buckets to receive the water in its downward flow and curved-iron buckets to direct this water back up stream, thus affording a comparatively quiet waterway. It is fairly efficient for certain species when kept free of trash, but shad do not appear to use it.

WINYAH BAY AND TRIBUTARIES.

Winyah Bay, the confluence of Waccamaw, Pee Dee, Black, and Sampit rivers, is one of the principal shad-producing regions of the Southern States. This bay possesses characteristics to be found at the mouths of many of the large streams in the South. The length approximates 12 miles, the width ranging from ¾ to 4 miles, and the bottom is of shifting sand, in which numerous channels have been washed by the tide.

From the outer entrance of the harbor to Georgetown, a distance of 14 miles, also for 30 miles up the Waccamaw and at the mouths of Sampit and Black rivers, the water is well filled with drift nets from the middle of January to the end of March, this being the only apparatus used for taking shad. In 1896, 254 drift nets were used in the waters tributary to Georgetown, the length ranging from 200 to 600 yards, with mesh from $5\frac{1}{8}$ to $5\frac{3}{4}$ inches, and depth from 40 to 60 meshes. Two men are required for each boat, the men being mainly negroes, many of whom find employment during the rest of the year in the rice fields or the turpentine woods.

The season begins usually during the second week in January and continues until some time in April, with the weekly close times operative in this State.

The catch in 1896 numbered 40,411 roe shad and 39,658 bucks, the local value being $18,454. In addition, 14,246 hickory shad were taken, worth $1,068. Most of the latter were females, the large mesh of the nets permitting the buck hickories to escape. This fishery has not been profitable for several years, the total receipts barely paying for the twine used.

The season in 1896 closed earlier than usual, the low prices in the Northern markets not warranting shipments after the first week of April. In the first part of the season the buck shad largely outnumber the roes, but later the proportion is reversed, resulting in about an equal division between the two. The following shows the number of each sex handled monthly by one Georgetown firm in 1896:

Month.	Buck shad.	Roe shad.	Per cent of bucks.	Per cent of roes.
January 11–31	2,939	452	86.67	13.33
February	12,603	5,232	70.66	29.34
March	8,133	17,345	31.92	68.08
April 1–3	30	152	16.48	83.52
Total	23,705	23,181		

The shad fisheries of Winyah Bay are of comparatively recent development, being the result of the tendency in the fisheries on all of the Atlantic coast streams toward concentration at points nearest the mouth possessing the most convenient shipping facilities, and yet where the river is sufficiently narrow to render very costly apparatus unnecessary.

The following summary shows, for certain years, the number of drift nets and the total and average catch of shad per net in the vicinity of Georgetown:

Year.	Number of nets.	Number of shad taken.	Average per net.
1880	30	26,000	867
1889	220	90,000	409
1890	150	86,719	578
1896	254	80,069	315

The tributaries of Winyah Bay are Waccamaw, Pee Dee, Black, and Sampit rivers, all having shad fisheries of more or less importance, and which will be described successively.

Waccamaw River.—Waccamaw River has a total length of 149 miles, the lowest 26 of which forms the main channel of Pee Dee River, and is of considerable size. For the succeeding 24 miles, to Conway, it is navigable for vessels of 7 feet draft, while steam navigation with 3 feet draft is carried on 68 miles farther, to Reeves Ferry, N. C., 31 miles from Lake Waccamaw, the head of the river.

In its lower portion, below Brook Green, the shad fisheries of the Waccamaw are of much importance, a large number of drift nets being used. These are tributary to Georgetown, and have already been noted in the description of the fisheries of Winyah Bay. The nets are from 200 to 300 yards long, 16 to 20 feet deep, with $5\frac{1}{4}$ to $5\frac{1}{2}$ inch mesh. In 1896 the season began January 18 and ended somewhat later than in Winyah Bay. It was noticed during that season that the greater part of the shad were taken near the ends of the nets, the fish crowding the river banks rather than following the channel.

Above Brook Green shad are taken by means of bow nets by the planters and woodsmen living along the stream as far up as Conway, and occasionally at Red Bluff, 30 miles farther; and a few are sometimes taken even beyond the North Carolina line, over 100 miles from Georgetown by the river course. Other than that tributary to Georgetown, the shad fisheries of Waccamaw River are of small importance, and the inconvenience of ascending the river at the time of my visit renders it impracticable to present an exact statement of their extent. It is probable, however, that not exceeding 500 shad annually are taken on this stream above Brook Green.

PEE DEE RIVER AND TRIBUTARIES.

This is a river of many names. The lower 26 miles is known as Waccamaw River; next comes a length of 25 miles known as Bull Creek, the name Pee Dee being given to a series of small creeks and ponds from the head of Bull Creek to Winyah Bay. The succeeding 250 miles, from Bull Creek to the Narrows, is known as Pee Dee River, or the Great Pee Dee, to distinguish it from one of its tributaries called the Little Pee Dee. The name Yadkin River is applied to the 210 miles of

length above the Narrows. In this report the name Pee Dee is applied to the entire stream above Waccamaw River.

The Pee Dee is one of the principal streams on the southern coast. It rises on the eastern slope of the Blue Ridge in Watauga County, N. C., and before its entrance into Waccamaw River flows a distance of about 485 miles, of which 213 miles are in South Carolina and 272 miles in North Carolina. It is navigable for steamers of 3½ feet draft for a distance of 230 miles above Georgetown, two steamers running regularly and going as high as Cheraw when practicable. In discussing the fisheries of this stream it is natural to divide it into three sections—(1) the lower 204 miles of the river, being from the Waccamaw to the lowest dam near Cheraw, covering the navigable portion; (2) from Cheraw to the Narrows, a distance of 71 miles, containing numerous dams and other obstructions to the passage of fish; and (3) the 210 miles above the Narrows, known as the Yadkin.

From the Waccamaw to Cheraw.—The lower portion of the Pee Dee possesses the usual characteristics of South Carolina streams. The banks are low and swampy, occasionally varied by bluffs; the width varies from 150 to 300 feet at low water, and the slope averages 0.279 foot per mile. The course is extremely winding, being almost a continuous series of semicircular curves, requiring 203 miles to traverse from the Waccamaw to Cheraw, whereas in a straight line the distance is less than 100 miles.

Shad are obtained throughout this length of the Pee Dee, but in no great abundance at any point. From the Waccamaw to Mars Bluff they are at present taken only by means of bow nets; drift nets have been used to some extent, but the numerous logs and snags in the river prevent the successful prosecution of that form of fishery. From Hunt Bluff to Cheraw, a distance of 50 miles, seines and drift nets are employed. During 1896 the total number of shad taken on this length of the river was 8,967, of which 7,759 were taken by bow nets, 1,018 by seines, and 190 by drift nets.

The bow nets are employed most extensively at Smith Mills, Dunham Bluff, Savage Landing, Stone Landing, Drewit Bluff, Birch Ferry, and Crawford Landing. The season begins about February 10 and lasts generally 2½ months, the catch ranging from 20 to 200 shad per boat. It is said that twenty years ago the boats usually caught 20 to 40 shad each per night. In 1890 the average catch per boat for the entire season approximated 114, and during 1896 the average for the 168 bow nets used between the Waccamaw and Mars Bluff was 46 for the season. The catch in 1895 was considerably more than in 1896, but in 1894 it was somewhat less than in 1895 on account of the prevalence of low water in this portion of the river.

Between Hunt Bluff and Cheraw there were formerly numerous seine fisheries, but on account of the increased scarcity of shad these have been greatly reduced, both in number and in size. The lowest is at Hunt Bluff, 15 miles below Society Hill, where two small seines

were used in 1896, yielding 152 shad. About 10 miles above Hunt Bluff is another seine bar, where two short seines were used in 1896, the catch approximating 56 shad and 1,000 hickories. Just above Douglass Falls and about 3 miles below Society Hill a small seine was used, catching 22 shad and 280 hickories. About 4½ miles above Society Hill and 17 miles below the lowest fishing dam a double-seine fishery was operated, the catch numbering 790 shad, of which 470 were bucks. The season was quite short, extending only from March 1 to April 5. It thus appears that in 1896 there were but 4 seine fisheries operated below Cheraw, yielding 1,018 shad, of which 594 were bucks. If the present scarcity of shad continues, even these fisheries will doubtless soon be abandoned.

In the neighborhood of Society Hill there are 4 drift nets, used by as many negroes, in the capture of shad. These nets are 32 yards long and have 5½-inch mesh. On account of the clearness of the water it is necessary that the fishery be carried on at night instead of during the daytime. The season begins March 1 and lasts about six weeks, the men fishing about four nights each week. In 1896 190 shad were taken, of which 103 were bucks. Between Society Hill and Cheraw shad are first taken by both seines and drift nets about six weeks later than in the vicinity of Georgetown, and as the distance is 230 miles, it appears that they travel about 5½ miles per day.

From Cheraw to the Narrows.—The second of the three sections into which it has been found convenient to divide Pee Dee River extends from Cheraw to the Narrows, a distance of 71 miles.

Throughout this length of the river the current is quite swift, the descent being about 355 feet, an average of 5 feet to the mile, but in places exceeding 20 feet to the mile. There are numerous fishing-dams along this stretch of the river, with from 1 to 2 feet fall. The dams are constructed of rough stone masonry, or by filling a log cribbing with rocks, at convenient points where the river is narrow and shoal, the cost ranging from $100 to $1,500 each. While these dams frequently extend across the stream, there are generally thoroughfares around them, and at high water, which usually prevails during the shad season, they are partly submerged, permitting many fish to pass over. Numerous sluices are left for the passage of water, in which are placed the fall traps and wheels for catching the fish.

The fall traps differ little from those in use in many of the Atlantic coast streams, and, being placed so as to catch the fish going down the river, take very few shad during the upward run. They are 25 to 30 feet long, 6 to 8 feet wide, with a descent of about 5 feet, and cost from $20 to $60 each.

The wheels, which are intended especially for shad, are somewhat similar to those used in the Columbia River salmon fisheries. They are said to have been introduced in the Pee Dee about 1846, antedating by over thirty years those used on Columbia River. They consist of two or more curved wings, 5 to 7 feet long, attached to a rotary shaft

fixed in the sluiceway. The wings consist of wooden frames covered with small slats or twine and so arranged that, the wheel being fixed in the sluice and rotated by the downward current of water, the fish ascending the stream are caught and carried up by the wings and shunted into a box or barrel placed at the side of the wheel, whence they may be removed at leisure. The entire apparatus is constructed quite cheaply, costing about $6. In addition to shad these wheels take suckers, catfish, redhorse, white perch, carp, etc., the value of the annual catch being from $50 to $300 at each fishery.

The lowest of the fishing-dams on Pee Dee River is about 1 mile above Cheraw and consists of 1 wheel and 3 fall traps, the length of the dam being 280 yards. The catch at this fishery in 1896 was 100 shad. About 2 miles farther up is a dam 100 yards long containing 2 wheels and 2 fall traps, yielding 96 shad in 1896. Each of these fisheries is small and only imperfectly obstructs the passage of fish.

About 4 miles above the lowest dam is a seine fishery, at which two seines, each 100 yards in length and with 2-inch mesh, are operated in the spring. In 1896 they were hauled from March 15 to April 30, about 18 times each per day during five days of each week, catching shad, redhorse, carp, fat-backs, suckers, etc. The yield of shad was 280 roe and 310 buck, against a total of 300 in 1895.

Three miles above this seine bar is a fishery, which yielded 120 roe and 136 buck shad in 1896. In 1895 it consisted of 14 wheels only, but in 1896 it had 23 wheels and 3 fall traps. A mile or so above the preceding, is the Pollock fishery, containing 23 wheels and 7 fall traps. In 1896 it yielded 102 roe and 108 buck shad. Less than 2 miles above is the Pegues fishery, a half mile below the North Carolina State line, and containing 13 wheels and 3 fall traps which yielded in 1896 18 roe and 14 buck shad. These fish-dams make pools above them 2 feet deep, and back the water up about half a mile.

One mile above the North Carolina line is the Manship fishery, entirely crossing the river, containing 22 wheels and 7 fall traps, and yielding 5 roe and 7 buck shad in 1896, and about 95 shad in 1895. The Dockery fishery, containing 14 dippers and 2 fall traps and yielding 1 roe and 1 buck shad in 1896, and about 60 shad in 1895, is located a short distance below the Carolina Central Railroad bridge, 8 miles above the South Carolina line.

Six miles above the railroad bridge comes the Ingram fishery, consisting of 10 wheels and 3 fall traps. The dam at this fishery entirely crosses the river proper, but fish may ascend by a small thoroughfare which passes around an island at this point. No shad were taken here in 1896; in 1895 the catch approximated 125, of which about 40 per cent were roe. This fishery was established about 1865, it originally containing but 8 dippers, the catch at that time averaging about 5,000 shad annually, selling at from 5 to 6 cents each. From 1890 to 1894 the annual yield was about 300 shad.

Next comes the Grassy Island fishery, 17 miles above the South Carolina line and 25 miles above the lowest dam near Cheraw. This contains 25 wheels and 2 fall traps, the yield in 1895 being 305 shad, but only 2 in 1896, both of which were bucks. This appears to be the highest point to which shad ascended the Pee Dee in 1896. The catch during the first season following the establishment of this fishery, about 1875, approximated 17,000 shad. A short distance above the Grassy Island fishery is the Upper fishery or the Grassy Island Upper fishery, consisting of 14 dippers and 3 fall traps. There is a small island in the river at this point and 12 of the dippers and 2 traps are located in the main channel of the stream, and 2 dippers and 1 trap in the side channel. These caught 192 shad in 1895, but none whatever in 1896.

Joseph Aldman's fishery, 50 miles above Cheraw and 21 miles below the Narrows, containing 2 wheels and 2 fall traps, has yielded no shad since 1894, when it caught 1 buck. Ten to twelve years ago this fishery yielded about 100 shad each season. A number of fishing-dams in this vicinity have been permitted to go to waste on account of the scarcity of fish. Sampson Parker has a fishery 13 miles below the Narrows and 58 miles above Cheraw which contains 3 wheels and 1 fall trap, the dam entirely blocking the river. This fishery took no shad in 1896 and only 2 buck shad in 1895. This is the highest point on the river at which shad have been taken since 1892. Six miles below the Narrows is Kirk's fishery, consisting of a dam partly blocking the river, containing 2 fall traps, which have taken no shad during the last five years.

At the Great Falls or the Yadkin Falls, 2 miles below the Narrows, there are 3 dippers, which have yielded no shad since 1892. A fishery of 2 or 3 dippers, about 1 mile below the Narrows, has taken no shad since 1891. In the case of the two latter there are no artificial dams, the dippers or wheels being located in the favorable sluices in the rocky course of the river, and in no case do they entirely block the channel. Numerous other dams formerly existed in this length of the river, especially between Grassy Island and Great Falls, but the unprofitableness of the fishery has led to their abandonment.

It thus appears that from Cheraw to the Narrows, a distance of 71 miles, there are at present 16 wheel and fall-trap fisheries, which more or less effectually obstruct the free passage of fish. All of these were originally constructed for catching shad, but in 1896 not a single shad was taken in the upper six fisheries, only 4 in the next three, and the total yield of shad in the 16 was but 710, of which 342 were females. In 1895 the catch in the same apparatus was 2,229 shad. The decrease was especially apparent above the Broach and Quick dam, the catch above that point being 258 in 1896 against 1,469 in 1895. The catch from the Broach and Quick dam to the lowest dam, including Sherrel's seine bar, was 1,042 shad in 1896 and 1,060 in 1895. It should be noted that the Broach and Quick dam was enlarged in 1895 so as to

extend quite across the stream. and that the lowest dam was not completed until 1896.

The Narrows is a remarkably picturesque series of rapids confined between high cliffs, with a length of about 4 miles and a total descent of 105 feet. Forty years ago Judge Locke had six or eight fishing "stands" in the Narrows each year, which are reported as having yielded on certain days as high as 300 shad each. Many of these were sold fresh to hucksters, who disposed of them in the neighboring settlements, and the rest were salted for use on the plantations.

Mr. Wesley K. Littleton has maintained a fishery there since 1880, having in that year 2 dippers or wheels, which caught about 300 shad in the season, lasting during March, April, and May. The catch has decreased constantly since 1880. In 1892 only 2 shad were taken, and none whatever since then, although the fishery has been increased to 7 dippers.

From the Narrows to the headwaters.—From the head of the Narrows to the Richmond and Danville Railroad bridge near Salisbury, a distance of 43 miles, the Pee Dee has a width of 500 to 1,800 feet, a depth usually of less than 3 feet, and an average slope of over 5 feet per mile, and contains a dozen or more shoals with plunges from 1 to 6 feet. Prior to 1890 shad were occasionally taken in the numerous fish-dams located in this length of the river, but I have learned of none whatever being taken since that date. The catch consists principally of redhorse, suckers, carp, fatbacks, etc.

From the Richmond and Danville Railroad bridge to the foot of Bean Shoals, a distance of 64 miles, the river has an average slope of a little over 2 feet per mile, the elevation at the foot of Bean Shoals being 725 feet above sea level. In this stretch there are numerous fish-dams, several occupying the full width of the river, and a number of shoals, none of which have a vertical fall of more than 2½ feet. From the foot of Bean Shoals to Wilkesboro, a distance of 57 miles, the slope approximates 3 feet per mile. This stretch of the river contains 25 or more old fish-dams, and but few vertical falls of more than 1 foot. The elevation of the river at Wilkesboro is about 931 feet above sea level. Col. John A. Holt, of Salisbury, N. C., reports that thirty or forty years ago shad were caught in considerable numbers at the various fisheries between Salisbury and Bean Shoals, occasionally at Bean Shoals, and rarely at Wilkesboro. Needless to state, they have not been seen in these waters for many years, the extensive fisheries and the numerous dams below preventing their ascent.

Lynch River.—Of the numerous tributaries of the Pee Dee, Lynch River affords the longest run for shad. This river rises in Union County, N. C., and after flowing a distance of 200 miles enters the Pee Dee about 86 miles above Georgetown. The stream is quite shallow and narrow and its drainage small; at one point near its mouth it is but 20 feet in width, and at numerous other points the water is not over 1 foot deep. A small skiff can not navigate the river without

frequently stopping to haul over obstructions. Notwithstanding the adverse physical conditions, Lynch River is well adapted to shad, and those fish ascend as far up as Tilley Ferry, 125 miles above the mouth, and are taken in considerable numbers at Cartersville and lower points. Bow nets only are used, and as there are no important settlements on the river the fisheries are of small extent, the number of shad obtained below Cartersville in 1896 being 820, the nets used numbering 25.

Little Pee Dee River.—Little Pee Dee River, one of the principal tributaries of Pee Dee River, rises in the southern part of North Carolina, and after flowing 75 miles enters the Pee Dee about 56 miles above Georgetown. So far as could be learned, no shad whatever are caught on this stream, nor have they ever been obtained there in large numbers, due, probably, to the fact that the Little Pee Dee is sluggish, with abundant seepage, the river course broadening in many places into small lakes.

Black River.—Black River has its sources in Kershaw and Sumter counties, flows over 150 miles, and enters Winyah Bay near Georgetown. From the mouth to Pine Tree Landing, a distance of 45 miles, the river is deep and navigable for vessels of 10 feet draft. Thence to Potato Ferry, 11 miles distant, it is shoal, averaging not over 3 feet in depth, and the bottom rocky. Above Potato Ferry the water is less than 1 foot in depth at low stages.

Shad are taken on this stream as far up as Mouzans, over 130 miles from Georgetown, and considerable fisheries exist below Harpers, especially in the neighborhood of Pine Tree and Pitchkettle. Except in the extreme lower end, bow nets only are used, the number employed in 1896 being 65 and the catch amounting to 5,825 shad, of which 3,545 were roes. The yield on the Black River has very much decreased in recent years, as is also the case with most of the rivers tributary to Winyah Bay. Twenty years ago 25 to 30 shad were nightly taken by each bow net, whereas in 1896 the average catch was but 2 to 4 per night. The catch in 1896 was much less than in 1895.

The shad season on the Black River begins about February 10, one month later than in Winyah Bay. Several drift nets are used near the mouth of the Black River, but these have been included with the fisheries of Winyah Bay.

Sampit River.—The Sampit is a small stream rising in Sampit Swamp and entering Winyah Bay just below Georgetown. In the lower part a few drift nets are used by Georgetown fishermen, but these have been listed with the Winyah Bay fisheries. The planters and woodsmen for a distance of 20 miles up the river use bow nets, taking sufficient shad for local use, the catch in 1896 numbering 720, of which 60 per cent were bucks. Mr. D. B. Bourne, of Sampit, reports that shad are as abundant in this stream at present as they ever were.

The fisheries of Winyah Bay and tributaries have been described with much detail, as they represent the modified conditions that are more or less in evidence in most of the Atlantic coast streams, the cor-

rect understanding of which is quite important. Formerly the shad fisheries of these waters extended as far up as Bean Shoals, on the Upper Pee Dee, a distance of 382 miles from the ocean. There was no concentration at any particular point, and the local demand that existed in any section did not warrant the prosecution of the fisheries so vigorously as to cut off the run of shad at points above. About 1846 the use of dams for catching shad was introduced in this river, and during the first few years following the adoption of this form of apparatus large catches were made. It is reported that 17,000 shad were taken at one dam during the season immediately following its construction, and it is probable that prior to 1860 the catch in that portion of the Pee Dee located above the North Carolina line numbered over 100,000 annually. The multiplication of dams resulted in shutting off the fish from the upper reaches of the river, where the best spawning-grounds are located, and the run so decreased that in 1896, as already shown, only 16 shad were taken in that section.

A no less important change has occurred in the lower half of the river. The profits derived from shipping fish to northern markets have resulted in a concentration of the fisheries at the point nearest the mouth of the river where the most convenient shipping facilities exist. This not only secures the shad much earlier than if the fisheries were prosecuted at a distance from the mouth, but it affords an unobstructed passage from the ocean, the run not being cut off by other fisheries. Of the 97,685 shad taken in Winyah Bay and tributaries in 1896, 82,500, or 85 per cent, were caught within 30 miles of the ocean, practically none of which had spawned. Of the remaining 15,185 taken at a greater distance from the ocean, the percentage that had spawned is, indeed, very small. This has so reduced natural reproduction as to make it almost an insignificant factor in keeping up the supply, and renders artificial propagation essential to the prosperity of the fisheries.

The inquiry on the Pee Dee was begun at Salisbury, N. C., the writer traveling the banks of the river to the ocean. Many of the fishermen living between Salisbury and the Narrows were strongly of the opinion that a wire net was stretched across the river near Grassy Island, so as to prevent the further ascent of shad. The fishermen of Grassy Island were no less emphatic in their assertion as to the existence of the wire net, but its alleged location was near Cheraw. At Cheraw and for many miles below that city statements as to the wire net were heard, but the location was fixed near the mouth of the river. When that point was reached it was found that the much-talked-of obstruction had no existence except in the imagination of the fishermen. Although the wire net does not exist, yet the stream is so narrow that it is almost completely obstructed by an amount of twine which would have little appreciable effect in retarding the run of shad up the broad tributaries of the Chesapeake or up the Delaware.

THE SHAD FISHERIES OF NORTH CAROLINA.

As determined by the number of persons employed, the amount of capital invested, and the value of the catch the shad fisheries of North Carolina are the most important on the Atlantic coast. The following tables show the extent of the fisheries by water-courses:

Statement, by water areas, of the number of persons employed in each branch of the shad fisheries of North Carolina in 1896.

Waters.	Number of fishermen.						Trans-porters.	Shores-men.	Total, exclusive of duplication.
	Drift-net.	Stake-net.	Seine.	Pound-net.	Bow-net.	Wheel.			
Cape Fear River and tributaries:									
Below Black River	222								222
Above Black River	148		20		248				399
Black River			82		120				148
North East River	24		71						94
Pamlico Sound		368		82			20	13	483
Neuse River and tributaries:									
Below Contentnea River	76	86	315	58	360			28	911
Above Contentnea River		2	45		490				517
Contentnea River		68	40		138				209
Little River			8		38				44
Pamlico River	46	24	149	16	44		5		260
Tar River			40		186				208
Croatan Sound		82	30	72			5	29	218
Roanoke Sound		4		4					8
Albemarle Sound		331	121	229			30	519	1,229
Pasquotank River		2	47	9	20			20	98
Perquimans River		30	30	29				15	104
Roanoke River	36	2	169		870	17		67	1,161
Chowan River	14		190	191				239	634
Total	566	999	1,357	690	2,514	17	60	930	6,947

Statement, by water areas, of the boats, apparatus, etc., employed in the shad fisheries of North Carolina in 1896.

Waters.	Boats.		Drift nets.			Stake nets.			Pound nets.	
	No.	Value.	No.	Length.	Value.	No.	Length.	Value.	No.	Value.
Cape Fear River and tributaries:				*Yards.*			*Yards.*			
Below Black River	111	$1,403	113	21,010	$3,634					
Above Black River	218	732	99	2,692	691					
Black River	79	358								
North East River	29	151	12	1,520	410					
Pamlico Sound	235	21,650				24,808	458,524	$30,001	171	$13,885
Neuse River and tributaries:										
Below Contentnea River	423	10,983	38	4,280	676	3,240	64,809	3,686	87	10,378
Above Contentnea River	269	858				6	132	18		
Contentnea River	127	337				178	1,804	241		
Little River	19	62								
Pamlico River	134	4,050	23	2,300	197	840	16,800	985	27	3,325
Tar River	108	342								
Croatan Sound	75	6,210				5,625	108,420	7,516	140	10,825
Roanoke Sound	4	360				225	4,500	281	3	300
Albemarle Sound	319	23,622				21,985	432,488	29,944	612	56,215
Pasquotank River	24	590				100	1,800	125	17	1,550
Perquimans River	36	1,800				765	14,295	1,032	71	6,075
Roanoke River	501	3,505	18	1,440	270	15	300	45		
Chowan River	120	3,375	74	1,440	185				447	29,530
Total	2,831	80,388	377	34,682	6,063	57,787	1,103,872	73,874	1,575	132,083

Boats, apparatus, etc., employed in North Carolina shad fisheries—Continued.

Waters.	Seines.			Bow nets.		Wheels.		Shore and accessory property.	Total value.
	No.	Length.	Value.	No.	Value.	No.	Value.		
Cape Fear River and tributaries:		*Yards.*							
Below Black River								$1,960	$6,997
Above Black River	5	346	$322	124	$330			1,450	3,525
Black River	21	630	436	60	150			2,100	3,044
North East River	17	902	481					2,200	3,242
Pamlico Sound								4,505	70,041
Neuse River and tributaries:									
Below Contentnea River	86	18,880	6,361	185	530			39,300	71,914
Above Contentnea River	12	826	331	257	705			3,000	4,912
Contentnea River	10	623	383	70	178			2,375	3,514
Little River	2	130	78	17	48			450	638
Pamlico River	40	18,035	6,933	22	66			4,900	20,456
Tar River	10	1,246	806	98	239			2,300	3,687
Croatan Sound	1	2,300	3,000					15,378	42,929
Roanoke Sound								70	1,011
Albemarle Sound	4	10,000	12,500					82,495	204,776
Pasquotank River	4	4,650	3,630	10	20			5,880	11,795
Perquimans River	2	2,300	2,600					5,250	16,757
Roanoke River	8	6,059	6,100	435	1,515	75	$1,125	34,267	46,827
Chowan River	8	9,740	12.600					36,002	81,692
Total	230	76,658	56,561	1,278	3,781	75	1,125	243,882	597,757

Statement, by water areas and apparatus, of the number of shad taken in North Carolina in 1896.

Waters.	Drift nets.		Stake nets.		Seines.	
	No.	Value.	No.	Value.	No.	Value.
Cape Fear River and tributaries:						
Below Black River	45,372	$11,333				
Above Black River	5,375	1,584			668	$200
Black River					3,745	958
North East River	4,062	1,033			6,989	1,589
Pamlico Sound			387,236	$96,249		
Neuse River and tributaries:						
Below Contentnea River	18,485	3,244	23,118	3,811	105,210	19,222
Above Contentnea River			824	208	6,108	1,340
Contentnea River			2,541	661	2,573	633
Little River					186	44
Pamlico River	5,221	1,139	8,114	1,632	32,178	6,161
Tar River					6,515	1,278
Croatan Sound			68,626	14,006	20,000	3,800
Roanoke Sound			5,000	1,084		
Albemarle Sound			429,599	82,664	132,213	25,401
Pasquotank River			1,000	190	4,642	893
Perquimans River			12,424	2,380	7,680	1,502
Roanoke River	4,000	480	6,100	1,195	143,809	16,043
Chowan River	500	97			60,450	11,835
Total	83,015	18,910	944,582	204,080	532,966	90,899

Waters.	Pound nets.		Bow nets.		Wheels.		Total.	
	No.	Value.	No.	Value.	No.	Value.	No.	Value.
Cape Fear River and tributaries:								
Below Black River							45,372	$11,333
Above Black River			6,719	$1,658			12,762	3,442
Black River			2,385	609			6,130	1,567
North East River							11,051	2,622
Pamlico Sound	60,853	$13,478					448,089	109,727
Neuse River and tributaries:								
Below Contentnea River	22,471	3,902	12,250	2,901			181,534	33,080
Above Contentnea River			11,067	2,599			17,999	4,147
Contentnea River			1,919	437			7,033	1,731
Little River			300	65			486	109
Pamlico River	7,759	1,538	1,010	209			54,282	10,679
Tar River			6,285	1,359			12,800	2,637
Croatan Sound	73,834	13,925					162,460	31,731
Roanoke Sound	2,081	386					7,081	1,470
Albemarle Sound	173,380	32,094					735,192	140,159
Pasquotank River	2,840	460	275	56			8,757	1,599
Perquimans River	12,718	2,417					32,822	6,299
Roanoke River			13,500	2,391	2,000	$380	169,409	20,489
Chowan River	122,595	22,490					183,545	34,422
Total	478,531	90,690	55,710	12,284	2,000	380	2,096,804	417,243

CAPE FEAR RIVER AND TRIBUTARIES.

The Cape Fear River is formed by the confluence of Haw and Deep rivers, in Chatham County, North Carolina, at a distance, following the river course, of over 200 miles from the sea. It is navigable for light-draft steamers as far as Fayetteville, 145 miles from the ocean. By means of locks and dams it was formerly navigable to the junction of Haw and Deep rivers, but these aids have long since been abandoned. From the sea to Fayetteville the slope is about 10 feet, whereas from Fayetteville to the foot of Smiley Falls, a distance of 42 miles, the slope is 35 feet. Below Smiley Falls there were formerly four dams, ranging in height from 5 to 15 feet, but these have not been in existence for many years. The lowest obstruction at present is Battle Dam, about 12 miles above Smiley Falls, built of wood, 11 feet high and 500 feet long, extending directly across the river. Two miles farther up is Buckhorn Dam, 3 or 4 feet high and about 1,000 feet long, which formerly backed the water up to the junction of Haw and Deep rivers, a distance of 8 miles. Each of these dams is now in bad condition, being broken down in several places. Haw and Deep rivers, which form the Cape Fear, rise in Guilford County, 80 miles above their confluence. They are small streams, with considerable descent, averaging about 7 feet per mile each, and with numerous shoals and falls, which present absolute barriers to the upward passage of shad.

There are two distinct geographical sections in the Cape Fear shad fisheries: (1) The Wilmington section, from the mouth of the river to the entrance of Black River, 15 miles above Wilmington, in which drift nets exclusively are used; (2) thence to Smiley Falls, 42 miles above Fayetteville, in which bow nets, drift nets, and seines are employed. Each of these will be described separately.

The Wilmington section.—The drift nets in the Wilmington section are operated from Deep Water Point to Dollison, 1½ miles below the mouth of Black River. The length of those in the lower reaches ranges from 150 to 425 yards each, the depth averaging 50 meshes, and the size of mesh being 5¼ and 5½ inches. The nets between Wilmington and Dollison vary in length from 100 to 135 yards each; otherwise they are similar to those operated below Wilmington. Occasionally a net is used in one of the lower reaches during the early part of the season and then cut in half and used as two nets in the upper reaches during the rest of the season. About 20 short nets were drifted in Brunswick River in 1896. This river or thoroughfare is about 12 miles long, leaving the Cape Fear River 4 miles above Wilmington and reentering it 4 or 5 miles below that city. The Brunswick nets are from 100 to 120 yards in length, with a valuation of about $21 each. In North East River, a tributary entering the Cape Fear at Wilmington, there are several nets operated between the mouth and Three Cypresses, the men living between Wilmington and Castle Hayne. These nets range in length from 120 to 150 yards, the depth and mesh conforming to those on the Cape Fear between Wilmington and Dollison.

The total catch of shad in 1896 in the Cape Fear below Dollison, in Brunswick River, and in Northeast River below Three Cypresses, numbered 49,434, of which 21,316 were roes. The legal season extends from January 1 to May 15, but actual fishing began January 21 and ceased April 18, a close time operating from 6 p. m. Saturday to 6 p. m. Monday and from 6 p. m. Tuesday to 6 p. m. Wednesday of each week. The length of the season is determined largely by the temperature and flow of the waters. A warm March and April shortens the season and low water has the same effect, each causing the fish to pass rapidly upstream. There were more shad caught in 1896 than in 1895, the season being longer. There have not been so many shad taken in this vicinity during recent years as formerly. The catch in 1891 was 55,976; in 1890, 60,695, and in 1889, about 70,000. In 1890 108 nets were employed; 115 in 1891, and 125 in 1896. This gives an average per net of 562 shad in 1890; 487 in 1891, and 363 in 1896.

During the early portion of the season three-fourths or more of the catch consists of buck shad. As the season progresses the proportion is more evenly divided, and toward the end the roes greatly outnumber the buck shad. During the season of 1896 roe shad constituted 43 per cent of the total catch. Ripe shad are not found until near the end of March, and they are most numerous about May 1; consequently, the fisheries yield few eggs suitable for fertilization, as they cease before the end of April. One Wilmington dealer, who handled 15,007 shad in 1896, reports that not over 12 of them had spawned.

From Black River to Smiley Falls.—In the second section of Cape Fear River the bow net is the principal form of apparatus employed. Indeed, this is the only apparatus used in the lower 35 miles, except two 30-yard drift nets at Indian Wells, which took 200 shad during the past season. Bow nets are used all along this stretch of the river, the number operated in 1896 being 124, which yielded 6,719 shad, valued at $1,658. This is said to have been the smallest yield ever known. The catch during 1895 was also extremely poor, the yield previous to that time running from 100 to 400 to the net. A number of hickories are also caught in the bow nets, the total yield in 1896 being 2,920.

From Kelley Cove to Elizabethtown, a distance of 35 miles, drift nets are used almost exclusively, the only exceptions being the two bow nets at Browns Creek and one bow net at Elizabethtown. There are also two drift nets at Indian Wells, and 61 between Harrison Creek and Fayetteville. These nets are 20 to 45 yards long, 7 feet deep, $5\frac{1}{2}$ to $5\frac{5}{8}$ inch mesh, and cost about $5 each. The season begins a week or more earlier than in the bow-net fishery and closes about the end of April. The catch in 1896 was very small, only 5,375 shad being taken by the 99 boats. The conditions of the water and river were favorable for a good run, but the fish did not make an appearance. Drift nets have been used in this length of the river only during the last ten years, bow nets being employed exclusively prior to that time. The change in form of apparatus is due largely to the removal of snags and

brush from the channel of the river, and also to the decreased run of shad, rendering improved forms of apparatus necessary.

The lowest seine beach on Cape Fear River in 1896 was operated at Prospect Hall, 22 miles below Fayetteville, by Mr. William Whitedge, using two seines 50 yards long, 6 to 11 feet deep, and with 3-inch mesh. The season extended from March 29 to May 14, and 123 shad were caught, the highest catch in one day by the two seines being 16. Near Fayetteville three seines were operated in 1896, catching 545 shad and 3,065 hickories. The seines are from 75 to 90 yards in length, 12 to 15 feet deep, with 3-inch mesh, and require the services of 4 men each. The lowest is located about 9 miles below Fayetteville, and 5 miles above comes William Field's seine beach, new in 1896. A short distance above Fayetteville is E. P. Power's beach, established thirty years ago, and catching 5,500 shad during the first season. In 1867, according to Mr. Powers, the catch of shad in the vicinity of Fayetteville amounted to about 22,000. The season at Fayetteville begins the last week in February, about one month later than at the mouth of the river. The distance between the two points being 145 miles, it appears that shad move up the river at the rate of about 5 miles per day.

Smiley Falls is practically the limit of the shad run on Cape Fear River, and the few fish that pass those falls find an impassable barrier 12 and 14 miles above at Battle and Buckhorn dams. The fisheries on this river are prosecuted so vigorously, however, that few shad now pass above Kyle Landing, 12 miles above Fayetteville. In Smiley Falls several finger traps take some shad each season, but fish are becoming so scarce as to render their use unprofitable.

Black River.—Black River, which flows into the Cape Fear about 15 miles above Wilmington, is of considerable importance as a shad stream. It is quite narrow, ranging in width from 350 feet near the lower end to 100 feet 50 miles above. About 56 miles from its mouth it receives a tributary somewhat larger than itself, the South or South Black River. This branch is slightly deeper and longer than the main river above this point, but it is reported that few shad ascend it. About 30 miles above the mouth of South River, Black River receives the Six Runs, a somewhat important shad stream. This is the head of navigation during high water, and ordinarily very little navigation exists above Point Caswell, 36 miles from the Cape Fear. There are no falls whatever on Black River, and shad may ascend to the uppermost limits. Most of the fish are taken between Point Caswell and Clinton, and on the Six Runs below the Clinton and Warsaw Railroad bridge, seines and bow nets being employed.

It is unlawful to fish with seines in Black River "from Cape Fear River to the mouth of Great Coharie, also in the Six Runs to where the Atlantic Coast Line Railroad crosses said stream, except on Tuesdays, Wednesdays, and Saturdays of each week from 1 o'clock a. m. to 11.45 o'clock p. m. on each of the days above mentioned, * * * from the 1st day of March to the 15th day of June in each and every year."

The seines are 20 to 55 yards long, 1½-inch mesh, and with depth from 10 to 12 feet. They are frequently hired out by the day to farmers or timbermen desirous of securing a supply of shad for home use, the usual compensation being $2 per day and the same amount per night. Because of the distance from markets and the desultory manner in which the fishery is carried on, the catch is not large for the number of seines employed. In 1896, 21 seines were used, of which 12 were located on the Six Runs and 9 on Black River. On the Six Runs the seine shores are between the mouth of the river and the crossing of the Clinton and Warsaw Railroad. Very few shad, however, are taken above Taylor's Bridge, not a single shad being reported above that point in 1890. The catch in the 21 seines in 1896 numbered 3,745, of which 1,985 were bucks. Sixty bow nets were reported in 1896, mostly on the Six Runs, below Taylor's Bridge, the total yield amounting to 2,385 shad. Very few shad from Black River and tributaries are sent to distant markets, most of them being used in the homes of the fishermen.

North East River.—This river rises in the northeast portion of Duplin County, and after flowing 120 miles through a swampy section empties into the Cape Fear at Wilmington. It is navigable for small steamboats a distance of 75 miles, to Hallsville. From that point to Kornegay, 15 miles, it is shallow and narrow—20 to 100 feet in width—with low banks. In the extreme lower portion of North East River some shad are taken by Wilmington drift-net fishermen, as already noted. In addition thereto, a number of men living about Castle Hayne use drift nets, sending their catch to Wilmington. Twelve boats were used in this fishery in 1896, the catch being 1,942 roes and 2,120 bucks.

The principal shad fishery of North East River is the seine fishery, which is prosecuted from Sandy Hill, 30 miles above the mouth of the river, to Kornegay, a distance of 83 miles. In this section there are about 30 seine beaches, but a decrease in the abundance of shad has caused the abandonment of many of them. The seines range in length from 30 to 100 yards, the depth from 8 to 20 feet, the mesh from 2 to 3 inches, and 3 to 5 men are required to each fishery. In 1896, 17 seines were operated, the total catch by which approximated 6,989 shad, of which 3,320 were roes. In 1890, an unusually good season for recent years, 27 seines were used and 18,135 shad were taken. In 1891, 29 seines were used and the catch amounted to 13,455. The reduced catch in 1891 and in 1896 was due to heavy freshets, causing a short season all along the middle and lower end of the river, and this also explains why the catch above Hallsville was larger in 1891 than in 1890. An interdiction exists against fishing for shad in North East River "from the 23d day of February to the 1st day of July each year, between the hour of 12 o'clock midnight on Saturday nights and 6 a. m. on Wednesdays of each week." The shad on this stream are very large, individuals of 7 or 8 pounds being occasionally taken, and the average weight of the females probably exceeds 5 pounds. Formerly most of the North East

River shad were shipped by rail to distant markets, but the small catch of recent years has not furnished a surplus above the local demand.

In New River, Stone Bay, and other estuaries between Cape Fear River and Cape Lookout no especial attention is given to shad, but several hundred are taken annually in the mullet fisheries. The number thus caught is increasing, and doubtless profitable fisheries could be established.

Cape Lookout marks a distinctive change in the physical characteristics of the Atlantic coast streams. Below that cape all the rivers empty directly into the ocean, maintaining their fluvial characteristics almost, if not quite, to the mouth. From Cape Lookout to Cape Cod the streams empty into large sounds or bays, as Pamlico, Albemarle, and Long Island sounds, and Chesapeake, Delaware, New York, and Narragansett bays. The river mouths are usually broad estuaries, resembling arms of sounds and bays rather than rivers. The Neuse and the Pamlico rivers, in North Carolina, and the James, Rappahannock, Potomac, and Choptank, of Chesapeake Bay, are examples of this type. Other streams north of Cape Lookout possess this characteristic to a greater or less extent. This physical change affects the shad fisheries in three important particulars, viz: (1) The use of fixed apparatus of capture, as stake nets and pound nets, is made practicable; (2) the excessive concentration of the fisheries near the mouth is restricted; and (3) the beginning of the season is delayed several days.

PAMLICO SOUND.

Pamlico Sound is an irregular body of water, covering about 1,660 square miles and separated from the sea by a long, narrow sand beach known as "The Banks." At the north end it communicates with Albemarle Sound through Roanoke and Croatan sounds, and on the south it joins Core Sound, much of the waters of those sounds passing through Pamlico Sound, and two large rivers, the Neuse and Pamlico, enter from the west. The waters of Pamlico Sound and its tributaries communicate with the sea through Ocracoke, Hatteras, New, and Oregon inlets, each less than half a mile across.

The shad fisheries of this sound, like those of most of the salt-water estuaries of the Atlantic coast, are of comparatively recent development, originating about 1873 and receiving their greatest development during the past ten years. They are located in the northeast third of the sound, east of a line drawn from Hatteras Inlet to Sandy Point, and nearly 90 per cent are above a line drawn from Sandy Point to New Inlet. The principal fishing stations are the marsh islands and points at the extreme upper end of Pamlico Sound, the most important of which are Roanoke Marshes, Hog Island, Buck Island, Stumpy Point, Sandy Point, and Old Point. Most of these stations are inhabited only during the fishing season, the men returning to their homes on the uplands at the end of the season. In addition to the above-named

stations, shad fishing is carried on by men living at Chicamicomico or Rodanthe, Clarks, and Hatteras, on the banks. Stake nets and pound nets are used, set in the same general vicinity, but the latter usually inshore of the former. At present the stake nets greatly outnumber the pound nets, but the latter form of apparatus is rapidly increasing in popularity.

The stake nets measure 16 to 18 yards in length, 6 to 16 feet deep, with 5¼ to 5½ inch mesh, and from 50 to 500 are set in a string. They are made of cotton twine and cost, with necessary appliances, about $125 per 100 nets, the twine being renewed each season. Some of the nets are placed in very shoal water, as on Duck Island Flats, where the depth averages about 3 feet, and in many places so shoal that the fishermen are compelled to jump overboard and shove the boat along while overhauling the nets. The nets frequently remain in the water from the beginning of the season to the close, whereas when set in fresh water they must be taken up and cleaned every week. The 24,808 stake nets set in Pamlico Sound in 1896 required the services of 184 boats, worth $18,785, and of 368 men. The season began the first week in February and continued until about the middle of April. The total catch numbered 387,236, of which 207,736 were roes and 179,500 bucks, the total valuation being $96,249.

The stake-net catch at the various stations is affected largely by the prevailing winds both preceding and during the fishing season, the former determining to a certain extent the salinity of the water. The temperature of the water and of the atmosphere also influences the yield on the various reefs. On the Duck Island Flats in 1896 the water was low and quite salty, causing many fishermen who usually occupy those grounds to set their nets in Croatan and Albemarle sounds. Contrary to expectations, shad were more numerous on the Duck Island Flats than for many years previous, and the few fishermen operating there obtained large results. At Hog Island, one of the most important fishing stations, and which is separated from Roanoke Island only by small creeks, the yield of shad was exceptionally large, over 90,000 being taken. The catch in 1895 was nearly as good; but 1894 and 1893 were poor seasons, the former being the worst during recent years. On Long, Pingleton, and Gibbs shoals the catch was only about two-thirds as great as in 1895, and the yield in the nets set by the "Bank" fishermen from Chickamicomico to Hatteras was also unusually small.

The pound nets operated in Pamlico Sound are of the type known as "Dutch nets," costing from $80 to $1,100 each. The "pound" is generally 10 yards square, the "heart" 45 yards on each side, and the "leader" from 100 to 350 yards long. The mesh in the "pound" is 2¼ inches, in the "heart" 3 inches, and in the "leader" 4 inches. They are set along the shore across the current in strings containing from 1 to 11 nets each. The number used in Pamlico Sound is constantly increasing and they are gradually superseding the stake nets. They are set

about the 1st of February and remain in the water until late in the spring, the bulk of the catch being obtained from February 15 to March 15. In 1896 there were 171 pound nets, with an aggregate value of $13,885. Of these, 11 were near Hatteras Inlet and the others in the upper portion of the sound. The yield consisted of 30,812 roe and 30,041 buck shad, with a local valuation of $13,478.

There are several interesting features in connection with the shad resources of this body of water in addition to the fisheries at present operated. It will be seen that the only communication between the sea on one side and Neuse and Pamlico rivers and Albemarle Sound and its numerous tributaries on the other, is through Pamlico Sound, the outlets of which are Ocracoke, Hatteras, New, and Oregon inlets, whose total cross-section does not exceed 1½ miles. Through these narrow inlets the entire yield of shad taken in Pamlico Sound and tributaries, exceeding 2,000,000 annually, must pass. An impression exists that shad winter in these sounds, and in substantiation of this theory it is contended that if they passed into the sound from the sea through any one or all of the four inlets they would be taken in the seines which have at times been operated in those narrow passageways. This result would not necessarily follow, however, for when the shad enter from the sea they are not schooling, but moving as individuals, and avoid the fishing apparatus. In comparatively few of the coast waters are shad taken as easily near the sea as farther inland. It will be observed that the large quantities of fish taken in Albemarle Sound and tributaries must pass through Croatan and Roanoke sounds, and yet only a small percentage are taken in the numerous pound nets and stake nets located in those bodies of water. If the fish remained in the sound during the winter they would doubtless be discovered, even if they kept near the bottom; furthermore, those nets set on the shoals near Hatteras Inlet catch shad several days sooner than those in the upper portion of the sound, indicating that the fish are traveling from the direction of the inlet.

NEUSE RIVER AND TRIBUTARIES.

The Neuse, the most important shad stream between the St. Johns and the James rivers, is formed in Durham County, N. C., by the junction of the Eno, Flat, and Little rivers, and from that point to New Berne it measures in its sinuosities a distance of 260 miles. Below New Berne its fluvial characteristics disappear and it becomes a broad arm of Pamlico Sound, 40 miles long. The head of navigation is at Smithfield, 150 miles above New Berne, at an elevation of about 100 feet above sea level. In addition to the tributaries forming its source, the Neuse receives the waters of Trent, Contentnea, and Little rivers, and some minor streams. Shad formerly ascended Neuse River to its uppermost limits, and extensive fisheries are said to have existed near Raleigh, 190 miles from New Berne. At present they ascend in small numbers some distance above Raleigh, probably as far as Fishdam, in Durham County, and local fisheries exist above Smithfield. The bulk

of the catch, however, is obtained within 22 miles below and above New Berne. For convenience of description, the shad fisheries of the Neuse are divided into two geographical sections, viz: (1) the lower 72 miles, from Pamlico Sound to Contentnea River, and (2) from Contentnea River to the headwaters.

From the mouth to Contentnea River.—Below Contentnea River the Neuse flows through a low, swampy, timbered section, the banks rising from a few inches to 4 or 5 feet above low water, and large areas adjacent being covered during slight freshets, which, however, are rarely sudden or violent. The width of the stream from Pamlico Sound to New Berne ranges from 6 to 1½ miles, and from New Berne to the Contentnea it is from 250 to 80 feet at low water.

The forms of apparatus used in the shad fisheries of this section of Neuse River are seines, drift nets, bow nets, stake and pound nets, the first-named being the most important. There are three branches of this fishery, viz.: (*a*) the large seines below New Berne, requiring the use of horses; (*b*) the seine beaches above New Berne, and (*c*) the so-called drag nets, which are small seines without permanent beaches, hauled in such places as, from time to time, present favorable inducements.

(*a*) The large seines below New Berne, 5 in number, are located on the south side of the river from 3 to 6 miles below the city. It is reported that the first haul seine was operated here in 1846 by Richard Felton, a fisherman from Albemarle Sound. These seines are from 800 to 1,200 yards in length, 15 to 18 feet in depth, with mesh from 2½ to 2⅞ inches, the value ranging from $300 to $450 each. Six men, two horses, and two boats are usually required, and the rental of the shores is from $50 to $100 each annually. Seining begins about the first week in February and continues until the second or third week in April. The total catch by the five seines in 1896 was 5,688 roe shad and 5,954 bucks, with a local valuation of $2,192. In addition to shad, these seines catch quantities of alewives and striped bass.

(*b*) The seines used at the beaches between New Berne and Contentnea River are from 80 to 240 yards long, with 2¼ to 3 inch mesh, 50 to 70 meshes deep, and cost from $30 to $75 each. An average of 3 men and 1 boat is required for each seine. At New Berne the season begins about February 10, but near the Contentnea it is from two to three weeks later. In 1896 there were 28 seine beaches, which yielded 82,512 shad, of which 49,987, or 60 per cent, were bucks. Fishing is carried on every day except Sunday, and even on that day when shad are running plentifully. The catch varies considerably from year to year, the height of the water being the most important factor. The banks are so low that during freshets many of the beaches are overflooded and fishing is suspended for several days or even weeks. Since the above cause permits the shad to pass the seines down the river, it naturally follows that the best seasons in the upper reaches are coincident with high water in the lower part of the river. A few beaches, however, are so situated as to make their best hauls during high water.

(c) The third class of seines, known as drag nets, are used at such places on the river as may appear most desirable from day to day, no specially prepared seining beach being necessary, the nets being "footed up" in the water. They are used from the mouth of the river up to Pitchkettle Creek, 22 miles above New Berne, and also to some extent in Trent River, near its mouth. The maximum depth of water suitable for operating them is 12 feet for beginning the haul and 4 feet for "footing up" the net. They average in length about 225 yards, and 50 meshes deep, the mesh being about 2½ inches. Three men and one boat are required for each, the value of the net averaging about $75 and the boat $45. It is stated that this form of apparatus was introduced here about 1840 by Capt. Isaac Lewis. Their success does not depend entirely on the catch of shad; indeed, that species constitutes but a small portion of the yield, the aggregate yield in 1896 being 4,951 roes and 5,095 bucks. The other fish taken are herring, white perch, suckers, pickerel, striped bass. black bass. etc. The use of these nets is increasing.

The stake nets in Neuse River are set in 8 to 10 feet of water and in strings of from 30 to 60 nets each on the sides of the channel of the river from Northwest Creek, 5 miles below New Berne, to Great Island, 11 miles above that town. They are about 20 yards long, 10 feet deep, with 5¼-inch mesh, and, with the necessary stakes, etc., cost about $115 per hundred. Generally 70 nets are used by each boat, the latter costing about $50 and requiring the services of two men. This is the earliest branch of the shad fishery on the river, the season beginning each year about January 25 and ending about the first week in April. The stake-net fishery is most profitable during periods of high water. In 1896 47 boats engaged in this fishery, using 3,240 nets, and the catch numbered 10,262 roe shad and 12,856 bucks, the local valuation being $3,811. An interdiction exists against this form of fishery, but it is not enforced. Most of the men using stake nets are residents of Carteret and Pamlico counties, hailing from Cedar Island and Hunting Quarter in the former, and from Goose Creek to Bay River in the latter county.

Drift nets are operated from a short distance above the New Berne wharves to 12 miles down the river. These nets are from 100 to 120 yards long, 5¼-inch mesh, and cost about $18 each. The season begins about the second or third week of February and closes the first week in May. In 1896 38 drift nets were used, the yield being 8,360 roe shad and 10,125 bucks, with a local valuation of $3,244.

Notwithstanding an interdiction against pound nets in the Neuse, the employment of this form of apparatus is increasing each year. It was introduced here about 1878, and in 1880 6 were reported. In 1889 and in 1890 the regulation against their use appears to have been enforced, no pound nets being reported in the returns for those years. But a few were introduced into the lower part of the river, where local sentiment was favorable, and the evasion of the law gradually extended. In 1896 87 pound nets were set between Trent River and Adams Creek,

34 on the north side of the river and 53 on the south side, in depths of water ranging from 6 to 12 feet. The leaders average 200 yards in length, and the mesh in the trap is from 2 to 1½ inches. The average value of the pound nets is about $120, many of them being constructed of twine used previously in seines. The season begins about August 15 and continues until early in May. Shad constitute only about 20 per cent in value of the total pound-net catch, the other species taken being herring, striped bass, sea trout, croakers, white perch, drum, pickerel, etc. The catch of shad in 1896 was 22,471, of which 12,972 were bucks, and of herring 1,146,280 were obtained.

While comparatively few shad caught by means of bow nets reach New Berne, yet the use of that form of apparatus between New Berne and Contentnea River is quite extensive, especially in the vicinity of Spring Garden, Cowpens, and Pitchkettle. They are used to the best advantage during high water, as then most of the seining operations are suspended by reason of the beaches being overflooded, leaving a greater number of shad to be taken in other apparatus, and for the further reason that the shad are less cautious during the muddy-water period and are more easily netted. The number of bow nets in use between New Berne and the Contentnea in 1896 approximated 185, requiring 180 boats, worth $620, and 360 men, and the yield approximated 5,800 roe shad and 6,450 bucks, valued at $2,901.

From Contentnea River to headwaters.—The apparatus used in the shad fisheries of Neuse River from the entrance of Contentnea River to Smith Mills, a distance of 125 miles, consists of bow nets, seines, and stake nets. Bow nets are used throughout the length of the river; seines are operated between the entrance of Contentnea River and Bear Creek, 37 miles, and stake nets are operated at the railroad bridge, a short distance below Kinston, 17 miles above the Contentnea.

The seines range in length from 50 to 80 yards, the depth averages 12 feet, and the mesh about 2½ inches. The season begins usually the first week of February and ends the second or third week of May, the annual rental being about $20 for each beach. The catch of shad by each seine in 1896 ranged from 25 to 1,350 in number. It is stated that the present catch in these seines is not one-fourth of the yield twenty years ago. The Bear Creek seine-hole, the uppermost beach operated at present, caught only 200 shad in 1896, whereas from 1880 to 1890 the average catch was about 1,000 each season. Until quite recently there were several seines on the Neuse between Bear Creek seine-hole and Smithfield, but unprofitable fishing led to their abandonment. In 1896 two seines were operated 50 miles above Bear Creek seine-hole, but on Little River, a tributary entering Neuse River near Goldsboro.

Bow nets are operated from the entrance of the Contentnea to Wilson Mills, the total number employed in 1896 being 257 and the yield of shad numbering 11,067. The distance from Wilson Mills to New Berne is 156 miles, and as New Berne is 80 miles distant from the ocean it follows that the shad taken at Wilson Mills have traversed at least 236

miles since leaving the sea. This is one of the most distant points from the ocean at which commercial shad fisheries are now prosecuted. It appears that the season in the upper portion of the river does not begin until the end of February, four weeks later than at the lower end of the river. The distance being about 135 miles, the progress of the shad up the river shows an average of 4 or 5 miles per day. There are probably a few bow nets operated above Wilson Mills, but the small extent of the fishery did not warrant an extension of the inquiry above that point.

The six stake nets operated on Neuse River above the Contentnea were set near the Kinston railroad bridge. The length of the nets was 22 yards each, the depth 35 meshes, and the size of mesh $5\frac{3}{8}$ inches. Two men and two boats were engaged; the catch by one boat was 774 shad and 7 rockfish, and by the other boat 50 shad were taken.

Trent River.—The Trent, the largest tributary of the Neuse, is of considerable width and depth, but draining only a small area of territory the current is sluggish. The drag-net and drift-net fishermen of New Berne operate in the lower end, but with this exception few shad are taken in this stream. It appears that they do not run far up the Trent in large numbers, probably on account of the sluggishness of the water and the consequent accumulation of drift and other refuse matter.

Contentnea River.—About 32 miles above New Berne the Neuse receives the waters of Contentnea River, sometimes called Moccasin River, the shad fisheries of which are almost as important as those of the Neuse above this point. This river flows about halfway between Neuse and Tar rivers. It is about 140 miles long and it is navigable as far as Stantonsburg, 63 miles above the mouth. Above Stantonsburg it is full of narrow rapids and abrupt falls, forming a barrier to the further ascent of fish as well as to navigation. The apparatus used in taking shad consists of seines, stake nets, and bow nets, the total yield on the river in 1896 being 7,033, of which 3,222 were roes. Of this catch, 2,573 were taken in seines, 2,541 in stake nets, and 1,919 in bow nets.

The length of the seines ranges from 30 to 80 yards, the mesh 2 to $3\frac{1}{2}$ inches, and the number of men required four to each seine. The beaches rent for $20 to $40 annually. In the lower part of the river the season begins about the last of February, but it is a week or more later above Snow Hill. During 1896 the catch was unusually small, owing to low water permitting the shad to be taken on the lower Neuse, the total yield in the 10 seines on the Contentnea being 2,573 in number. The Tingle Beach, 3 miles above the mouth of the Contentnea, caught 2,400 shad in 1895 and only 410 in 1896. The number of seines on this river is much less than formerly, there being 25 or more ten years ago. In addition to shad, the seines take herring, hickories, perch, bream, etc.

The stake gill nets used on Contentnea River are from 18 to 40 feet in length, with $5\frac{1}{2}$-inch mesh, and cost on an average about $1.50 each. From two to five nets are used by each boat. The season begins

about the end of February and closes the second week of May. The catch in the 178 stake nets set in 1896 was 1,499 roe shad and 1,042 bucks. Seventy bow nets were used on the Contentnea between the mouth and Stantonsburg, yielding 609 roe shad and 1,310 bucks. These bow nets differ in no particular from those used in taking shad in other Atlantic coast streams.

Little River.—About 2 miles above Goldsboro the Neuse receives the waters of Little River, which is nearly 100 miles in length. Shad ascend as far as Whitley Mills, about 15 miles from the mouth, the numerous milldams obstructing their further passage. In the length below Whitley Mills a few shad are taken by means of seines and bow nets, the season beginning about the end of February and ending during the second or third week of May. In 1896 two 65-yard seines were used on Little River, one 6 miles and the other 11 miles above the Neuse, the yield of shad being 186, of which 60 per cent were bucks. Bow nets are used at various points below Whitley Mills, the total number reported in 1896 being 17, with a catch of 300 shad.

PAMLICO-TAR RIVER.

Pamlico and Tar rivers are different sections of a single stream, the name changing near the town of Washington, N. C. The lower portion, Pamlico River, has a length of 37 miles, and the upper portion, Tar River, is 180 miles long, giving a total length of 217 miles. The Pamlico length is really an arm of Pamlico Sound, whereas Tar River has all the usual fluvial characteristics. Tarboro, 49 miles above Washington, is the present head of navigation. Above that town the river is 90 to 200 feet in width with a gentle slope, affording ample passage for the ascent of shad 36 miles to Rocky Mount, where further progress is barred by a natural fall of about 20 feet, utilized for mill purposes, the site of the first cotton mill in North Carolina, erected in 1817. The shad fisheries of Pamlico-Tar River extend from the mouth to a short distance below Rocky Mount, the yield in 1896 being 32,601 roe shad and 34,481 bucks. The apparatus used consists of seines, stake nets, drift nets, pound nets, and bow nets, the first named yielding nearly 60 per cent of the total product

Seines are operated from Core Point, 16 miles below Washington, to Pillsboro Landing, 33 miles above that town. Those below Washington range in length from 450 to 1,000 yards, and above that town the length of the seines is from 50 to 200 yards, one or two seines being used at each beach. The mesh is from 2 to 2½ inches in the bunt, and from 4 to 9 men are required for each seine. The season begins usually during the first week of February below Washington, and about two weeks later in the upper portions of the river. The catch in 1896 was the smallest for several years, the yield at the 32 beaches on the river being only 38,693 shad, while 30 seines are reported as taking 108,728 shad in 1890. The weather was unfavorable for an early start and high water limited the operations at many of the beaches. Of the yield

in 1896, 32,178 shad were obtained in Pamlico River and 6,515 in the Tar.

Stake nets are set along both sides of the channel of this stream from the mouth to the town of Washington. They average 20 yards in length, 10 to 12 feet deep, with 5⅜ to 5½ inch mesh, and are made of cotton twine, which must be renewed annually. In 1896 840 nets were used, set in strings of from 10 to 40 nets each. The season began the second week of February and closed about the end of April, yielding 4,260 roe shad and 3,854 bucks, with an aggregate value of $1,632.

During heavy freshets a number of drift nets are used in the river from 1 mile below Washington to the same distance above that town. These nets are about 100 yards in length, with 5⅜-inch to 5½-inch mesh, and cost $10 or $12 each. Two men are required for each net, and the boats used are worth $10 to $15 each. The catch is small, as these nets are used only when the water is high. In the 23 nets operated at times in 1896 the yield of shad was 5,221, of which 2,867, or 55 per cent, were roes.

The bow-net fisheries are operated at various points from Washington to 25 miles above Tarboro, the total number of nets in 1896 being 120, of which 22 were operated in Pamlico River and 98 in the Tar. In the lower part of the river two men are required for each net, but in the upper portion a few of the nets are operated by one man each. The catch in 1896 by those in the Pamlico end was 1,010 shad and in Tar River 6,285. Most of these shad are consumed by the families of the fishermen and their neighbors.

The few pound nets or Dutch nets in Pamlico River are set near the mouth of Pungo River, a short tributary of the former, from September until the following May, and in these some shad are taken. An interdiction exists against the use of this form of apparatus, resulting in restricting but not entirely prohibiting the fishery. In 1896 27 of these nets were used, aggregating in value $3,325, being set in strings with from two to four nets each. The catch of shad numbered 7,759, of which 3,926 were roes.

CROATAN AND ROANOKE SOUNDS.

These sounds, separated from each other by Roanoke Island, form the channel of communication between Pamlico Sound and Albemarle Sound, all the waters of the latter, including its numerous tributaries, passing through them. Croatan Sound is 10 miles long, 2½ to 4 miles wide, and averages 8 to 10 feet deep, the bottom being very uneven and broken. Roanoke Sound has the same length as Croatan Sound and is 1 to 2 miles wide and very shoal except in a narrow channel skirting the shore of Roanoke Island, where the depth averages from 8 to 12 feet. The bulk of the shad passing from Pamlico Sound traverse Croatan Sound, in which there are consequently important fisheries. In Roanoke Sound very little twine is set, and the experience of the fishermen indicates that few shad pass through that body of water.

Except one seine in the extreme upper end of Croatan Sound, stake nets and pound nets are the only apparatus used in these two water areas, and these catch almost an equal number of shad each.

The stake nets differ in no particular from those in use in the extreme northern part of Pamlico Sound. From 75 to 600 nets are set in a string, the nets averaging in length nearly 20 yards each. The strings are placed generally north and south, so as to present the least surface of resistance to the strong currents caused by prevailing winds. In Roanoke Sound there was but one string in 1896, containing 225 nets and set in the northern part above Dalby Point. In the Croatan 16 strings containing 3,220 nets were set in the eastern half, and 14 strings containing 2,405 nets in the western half. The number of men and value of boats and apparatus employed in each sound are shown in the tables. The catch of shad by 225 nets in Roanoke Sound was 5,000, of which about two-thirds were roes, and in Croatan Sound the stake-net yield was 37,598 roe shad and 31,028 bucks, with a local valuation of $14,006.

The pound nets average in value from $75 to $100 each and are set near the shores. In Roanoke Sound there were but 3 pound nets in 1896, while 140 nets were in Croatan Sound. Four men and a boat worth $150 were used to operate the former, and 72 men, with 34 boats valued at $1,530, were required in Croatan Sound. The catch by the former approximated 1,350 bucks and 731 roes, and by the latter the yield was 44,769 buck and 29,065 roe shad. The pound nets also caught 866,500 alewives and quantities of striped bass, squeteague, bluefish, mullet, etc.

In the extreme northern end and on the western shore of Croatan Sound a 2,300-yard seine was operated in 1896, requiring the services of 30 fishermen, 29 shoresmen and preparators, 1 open flatboat, and 2 steam scows. The size of mesh was from 2 to 3½ inches, the depth of water from 4 to 12 feet, and the yield of shad approximated 20,000, of which two-thirds were bucks.

It appears that the total catch of shad in these two sounds in 1896 by means of stake nets was 73,626, of which 56 per cent were roes; whereas the catch by pound nets and seines aggregate 95,915 shad, of which only 38 per cent were roe shad. This difference is due in a large measure to the size of the mesh in the gill nets, failing to hold many of the small buck shad, leaving a greater proportion to be taken in the pound nets. Except sufficient for local use, the fish are delivered by boat at the Old Dominion Wharf on Roanoke Island, and thence sent to Norfolk, where they are distributed to northern markets.

ALBEMARLE SOUND.

Albemarle Sound is formed at the confluence of Roanoke and Chowan rivers, extends eastward a distance of 60 miles, and connects with the northern end of Pamlico Sound through Croatan and Roanoke sounds. The characteristics of this sound differ little from those of the broad estuaries forming the lower end of Neuse, Pamlico, James, Rappahan-

nock, and Potomac rivers. It is a bay rather than a sound, receiving the latter designation from its association with other waters of this portion of the coast. The water is fresh except during periods of excessively dry weather or of prevailing southerly winds, when it becomes somewhat brackish at the eastern end near Croatan Sound. It is considered the largest coastal body of fresh water in the world, the width averaging 7 or 8 miles and the area approximating 450 square miles. It is remarkably free from strong currents and tides, except those of infrequent occurrence resulting from gales, and the depth of the bottom is quite uniform, averaging from 16 to 20 feet.

The shad fisheries of Albemarle Sound are among the most important on the Atlantic coast, stake nets, pound nets, and seines being extensively employed. Of the 735,192 shad caught in this body of water in 1896, 429,599 were taken by means of stake nets, 173,380 by pound nets, and 132,213 by seines. The principal fishing centers are Edenton, with 197 fishermen; Peter Mashew's Creek, 90 fishermen; Mackey Ferry and vicinity, 70 fishermen, and Pear Tree Point, 36 fishermen. Numerous other stations employ from 5 to 20 fishermen and a number of shoresmen and preparators. Elizabeth City and Edenton are the principal shipping centers.

The stake-net fishery is by far the most important, the yield exceeding by 40 per cent the aggregate catch in all other forms of apparatus. The nets average about 20 yards each in length and from 10 to 14 feet in depth, with from 5¼ to 5½ inch mesh. The total value of the 21,985 used in 1896, including stakes, ropes, etc., was $29,944, and 331 men were required to operate them. From 50 to 500 nets are set in each string, the general direction of the strings being at right angles to the current. They are located at various points throughout the sound, but are most numerous at the extreme eastern end, near the entrance into Croatan Sound. In an area of 25 square miles in that region there were 46 strings in 1896, containing 7,785 nets, 35 per cent of the total number in the sound. From this section to the mouth of the Roanoke River stake nets are set less numerously and at irregular intervals, but the number in the western end of the sound has greatly increased during the last two years. The catch in 1896 aggregated 185,701 roe shad and 243,898 bucks, valued at $82,664. The season began about the first of February and lasted until the middle of April. Most of the catch is carried to some station on the Norfolk and Southern Railroad and thence shipped to northern markets, Elizabeth City receiving the bulk of the catch, with Edenton a close second.

The pound nets in Albemarle Sound differ in no particular from those in the neighboring waters on the south. A few are located near Peter Mashew's Creek in the extreme lower end of the sound, but the greater portion are in the upper half, within the limits of Chowan and Washington counties. They are set along the shores with from 1 to 25 nets on each string. This fishery is of comparatively recent development, originating about 1870.

The following summary shows by counties its location and extent in 1896:

Counties.	No. of men.	Pound nets.		Boats.		Shad caught.		
		No.	Value.	No.	Value.	No. of roes.	No. of bucks.	Value.
Dare	28	*a* 48	$4,890	15	$2,200	11,490	17,220	$5,236
Tyrrell	16	*b* 33	2,625	8	510	2,947	4,730	1,447
Washington	61	163	15,230	62	1,558	10,668	19,046	5,484
Bertie	9	30	3,000	6	370	4,372	6,105	2,009
Currituck	4	2	200	2	100	200	253	88
Camden	2	*c* 8	800	1	40	1,050	2,000	550
Pasquotank	2	2	200	1	75	50	250	51
Perquimans	27	72	6,300	16	620	5,657	7,845	2,592
Chowan	80	254	23,060	64	3,729	28,101	51,396	14,637
Total	229	612	56,215	175	9,202	64,535	108,845	32,094

a Includes six nets in Alligator River. *b* Includes four nets in Little Alligator River.
c Located in North River.

Haul seines were the only apparatus of capture employed in the shad fisheries of Albemarle Sound until about 1860, and until quite recently they have been the principal apparatus. At the present time, however, they play a minor part in the shad fisheries of this region, only 4 being operated—3 on the shore of Chowan County and 1 in Bertie County. They average in length about 2,500 yards each and in depth 12 to 16 feet, with 2-inch mesh in the bunt and 3-inch in the wings. From 25 to 35 men are required at each fishery, and steamers or steam flats are used in hauling each seine. The catch of these four seines in 1896 was 69,857 roe shad and 62,356 bucks, with a local valuation of $25,401. In addition to shad, 4,235,324 alewives were taken, the value being $11,655. A very small quantity of striped bass, perch, and sturgeon are also caught in the seines.

To illustrate the comparative abundance of shad during the last half century, the following statement is presented, showing for a series of years the yield of shad at the Greenfield seine fishery on Albemarle Sound:

Year.	No. of shad.	Average for 5 years.	Year.	No. of shad.	Average for 5 years.
1852	13,849		1876	17,919	
1853	25,552		1877	14,603	
1854	36,979	33,419	1878	10,485	17,185
1855	54,910		1879	17,225	
1856	35,806		1880	25,692	
1857	26,344		1881	19,777	
1858	36,242		1882	21,000	
1859	37,818	36,609	1883	16,894	19,091
1860	49,427		1884	17,011	
1861 *a*	33,213		1885	20,774	
1866	43,862		1886	21,038	
1867	49,249		1887	22,600	
1868	37,566	41,746	1888	29,484	22,514
1869	44,695		1889	22,791	
1870	33,358		1890	16,655	
1871	31,991		1891	15,861	
1872	42,694		1892	26,163	
1873	40,245	40,639	1893	26,352	23,805
1874	54,870		1894	23,245	
1875	33,394		1895	27,403	
			1896	46,522	

a Fishing interrupted during 1862–65 on account of war.

The John Wood seine has made the following catches of shad and alewives each year since 1891:

Year.	No. of shad.	No. of alewives.
1892	25,521	1,513,873
1893	30,479	1,417,254
1894	16,630	1,404,596
1895	25,853	2,007,992
1896	38,000	1,300,000

The yield of shad in Albemarle Sound depends largely on the currents, especially on those flowing from the mouth of the Roanoke. That river brings down large quantities of muddy water, forming a decided contrast to the otherwise comparatively clear water of the sound. The strong winds sometimes drive this muddy water back and forth, seriously injuring the pound-net and seine fisheries covered by it. This was especially true in 1896, and to some extent in 1895. It is claimed that this muddy water is rather beneficial to the stake-net fishery, and it appears that in certain localities covered by it in 1896 the stake nets made good catches while few shad were taken in the pound nets in the same section. This is tending to increase the popularity of stake nets, and that form of apparatus is superseding the pound nets and seines.

Pasquotank River.—This is really an arm of Albemarle Sound, extending 15 miles inland, with an average width of 2 miles and depth of 10 or 12 feet. In 1896 8,757 shad were obtained in this river, of which 4,642 were caught by 4 seines, 2,840 by 17 pound nets, 1,000 by 100 stake nets, and 275 by 10 bow nets.

Perquimans River.—This is also an arm of Albemarle Sound, 12 miles long, and averaging over a mile in width, with 10 or 12 feet of water. The apparatus used consisted of stake nets, seines, and pound nets. Of the 12,424 shad taken in the stake nets, 60 per cent were bucks; of the 7,680 caught in seines, 53 per cent were bucks, and 60 per cent of the 12,718 taken in pound nets were of the same sex. The shad season in the Perquimans, as in the Pasquotank, is from the middle of February to the second week of May.

ROANOKE RIVER.

The Roanoke, the principal tributary of Albemarle Sound, is a narrow, rapid stream, formed by the confluence of the Dan and Staunton in Mecklenburg County, Va., whence it flows through a winding course, a distance of 198 miles, to its outlet. It is navigable for vessels of 10 feet draft from the mouth to Hamilton, 62 miles, thence for 5 feet draft 67 miles further to Weldon. The Roanoke differs from other large rivers emptying into the North Carolina sounds in that the fluvial characteristics continue quite to the mouth, the width below Weldon being only 100 to 200 yards. Excepting a few rocky places, the bed of the river is of sand, with generally an alluvial deposit over the sand near the banks. At Eton Falls, near Weldon, the river crosses the escarpment line, descending over 100 feet in a distance of 13 miles above that town, the

channel being very tortuous and the bed of the river interspersed with rocks and islands, most of which are submerged at high water. Above Eton Falls to the head of the river, a distance of 56 miles, the depth of water varies from 2 to 10 feet at low water, and the fall aggregates 146 feet, an average of 2.6 feet per mile. This portion of the river is navigated only by pole boats, and, while a few fish are found in it, there are no established shad fisheries.

The commercial shad fisheries of the Roanoke are confined to the extreme lower end, from the mouth to Williamston. The forms of apparatus employed are seines, bow nets, stake nets, drift nets, and wheels, named in the order of their importance; 80 per cent of the total yield being obtained by seines. The fisheries are centered principally at Plymouth, Jamesville, and Williamston, in addition to which there are numerous minor fishing stations.

Eight seines were employed in 1896, with an aggregate length of 6,050 yards and valuation of $6,100. Four of these were operated between Plymouth and the mouth of Cashie River, two a short distance above Plymouth, and two at Jamesville, 17 miles from the mouth of the river. The men required to operate these seines numbered 169; 30 boats, worth $1,815, were used, and the value of the shore property utilized aggregated $33,247. During the season herein reported the fish were late in coming up the river, resulting in a small catch and low prices. In 1895 one seine caught 11,000 shad in one week, three times as many as were taken in any one seine during the best week in 1896. The yield in 8 seines in 1896 was 95,359 bucks and 47,440 roes, with a local valuation of $16,043. This large proportion of bucks was due chiefly to the large size of mesh used in stake nets between the mouth of the river and the sea, permitting small fish to pass through.

The gill-net fisheries of Roanoke River are of little importance, owing to the rapidity of the current and the crookedness of the stream. A string of stake nets is set at the junction of the Cashie River with the Roanoke, near the mouth of the latter. Fifteen 20-yard nets, with 5⅜-inch mesh, were used there in 1896, the catch aggregating 6,100 shad. For a distance of 2 miles above and the same distance below Plymouth 18 80-yard drift nets, with 5-inch mesh, were operated in 1896. These required two men each, only one net being used to each boat. The catch was small, approximating 4,000 shad, most of which were consumed in the homes of the fishermen and their neighbors.

The bow nets used on the Roanoke below Palmyra numbered 435, requiring the services of twice that number of men. These nets are about 20 feet long, 8 feet wide, the bag having about a 5-foot hang. They had a poor season, taking only 13,500 shad, an average of 31 per net. Most of the catch by these nets is used locally.

In the lower end of Roanoke River a number of wheels are used, their form of construction (for a description of which I am indebted to Mr. John N. Cobb) being somewhat similar to those on Pee Dee River. The principal difference is that on the Pee Dee the wheels are fixed in

sluice-openings in dams, whereas navigation on the Roanoke prevents the construction of dams, and the fishermen secure two flat-bottomed, square-sided boats parallel to each other and about 6 or 8 feet apart, the boats being held in the current by means of a long sapling projecting from the bank. A strong axle is placed in a bearing on each boat, the ends of the axle projecting about 2 feet beyond the farther side. To one end of this axle, and sometimes to both, is attached a paddle wheel of rough boards, and in the middle of the axle and occupying the full space between the boats is fixed a large curved scoop of twine or latticed strips of wood, the scoop being so constructed as to shunt the fish into one or both of the boats when they are dipped up by the current acting upon the paddle wheels, whence they are removed at the leisure of the fishermen. The cost of each apparatus is about $15. In 1896 there were 75 of these wheels in the lower Roanoke, which were owned and operated principally by farmers living near the river banks. The catch aggregated 2,000 shad and also large quantities of hickories and alewives.

CHOWAN RIVER.

The Chowan is formed by the junction of the Blackwater and Nottoway rivers nearly on the line between North Carolina and Virginia, whence it flows with a sluggish current a distance of 55 miles to its entrance into Albemarle Sound. For the lower 20 miles the river averages 1½ miles in width and 15 to 20 feet in depth. Above Holiday Island the width gradually contracts to about 500 feet near the head of the river. The water is dark and clear, in marked contrast to the muddy water from Roanoke River. The shad fisheries of Chowan River are somewhat greater in extent than those of the Roanoke, and there is a remarkable difference in the forms of the apparatus used. Bow nets, stake nets, and wheels are not reported, and two-thirds of the catch is obtained by means of pound nets, in addition to which seines are the only important apparatus used. Most of the fisheries are prosecuted between the mouth of the river and Harrellsville.

There were formerly a large number of seines on Chowan River, but the unprofitableness of the fishery has led to the abandonment of many of them. In 1896 only eight were used, with an aggregate length of 9,740 yards and valuation of $12,600, requiring the services of 190 fishermen. Seven of the seines were hauled on the west side of the river and one on the east. The most important is the one used at the Willow Branch fishery, situated just above the mouth, on the west side, the annual catch by which frequently exceeds 35,000 shad and 1,500,000 alewives. The services of 23 fishermen and two steam flats are required to operate it, and 25 shoresmen take care of the catch. The yield of this seine in 1896 was 34,300 shad and 1,500,000 alewives. Of the remaining seven seines, two were operated at Coleraine in Bertie County, one below Canons Ferry in Chowan County, and two above Harrellsville, one at Winton and one at Mount Gallon, in Hertford County. The two last-named seines are short, averaging 200 yards each; the others range in length from 2,300 to 750 yards each. The catch in 1896, by the eight

seines above noted, was 60,450 shad, valued at $11,835, of which 28,150 were roes and 32,300 bucks. The catch of alewives during the same season amounted to 6,772,000. The season begins usually about March 12 and ends the second week of May, the maximum run being about the first half of April.

Chowan River has the most important pound-net fishery of the rivers south of Virginia, the number of those nets in 1896 being 447. They are small, averaging in value about $70 each. Several of them are constructed with a small heart inside of the usual one, but the value of this addition is not generally recognized. The pound nets are located from the mouth of the river to Mount Gallon and mostly on the east side, 311 being on that side in 1896, while 136 were on the west side of the river. They are set usually in strings containing from 2 to 20 nets, only 5 nets being set singly during the last season. The depth of the water ranges from 6 to 20 feet, and the season runs from about the second week of March to the middle of May. The yield of shad in 1896 numbered 122,595, valued locally at $22,490, of which 47,576 were roes and 75,019 bucks.

Above the railroad bridge at Tunis there were 13 rowboats engaged in drifting gill nets, 1,440 yards of twine with 5½-inch mesh being used. The catch was small, amounting to only 500 shad, which were used principally in the families of the fishermen. The water of the Chowan appears to be too clear for the profitable employment of gill nets.

THE SHAD FISHERIES OF VIRGINIA.

The following series of three tables shows by water areas the extent of each branch of the shad fisheries of Virginia during the season covered by the present report:

Statement, by water areas, of the number of persons employed in each branch of the shad fisheries of Virginia in 1896.

Waters.	Number of fishermen.					Total, exclusive of duplication.	Transporters.	Shoresmen.	Total.
	Stake-net.	Drift-net.	Seine.	Pound-net.	Miscellaneous.				
Chesapeake Bay:									
Eastern shore	......	......	......	109	......	109	8	......	117
Western shore	29	......	......	618	......	647	48	11	706
Mobjack Bay	......	......	......	96	......	96	......	......	96
James River and tributaries:									
Below Chickahominy River	152	......	18	12	......	184	......	......	184
Between Chickahominy and Appomattox rivers	14	340	27	......	......	379	......	......	379
Above Appomattox River	......	128	......	......	......	128	......	......	128
Chickahominy River	......	160	43	......	*a* 3	206	......	......	206
Appomattox River	......	50	20	......	......	70	......	......	70
York River and tributaries:									
York River	107	......	6	94	*b* 10	211	......	......	211
Pamunkey River	6	293	17	......	......	314	......	......	314
Mattaponi River	......	306	39	......	......	345	......	......	345
Rappahannock River:									
Below Deep Creek	......	......	......	116	......	116	......	......	116
Deep Creek to Leedstown	114	18	13	112	*b* 2	215	......	......	215
Leedstown and above	......	78	14	32	*c* 6	122	......	......	122
Potomac River:									
Below Mattox Creek	2	......	......	207	......	209	8	......	217
Above Mattox Creek	19	236	247	101	......	595	9	31	635
Total	443	1,609	444	1,497	21	3,946	73	42	4,061

a Hedge. *b* Fyke-net. *c* Fall-trap.

Statement, by water areas, of the boats, apparatus, etc., employed in the shad fisheries of Virginia in 1896.

Waters.	Boats.		Stake nets.		
	No.	Value.	No.	Length.	Value.
Chesapeake Bay:				*Yards.*	
Western shore	369	$26,505	810	12,740	$1,340
Eastern shore	57	3,995			
James River and tributaries:					
Below Chickahominy River	93	2,311	3,498	34,898	3,681
Between Chickahominy and Appomattox rivers	181	2,225	235	2,440	224
Above Appomattox River	64	610			
Chickahominy River	172	1,406			
Appomattox River	30	365			
York River and tributaries:					
York River	110	5,157	990	6,461	764
Pamunkey River	159	1,530	53	378	38
Mattaponi River	162	1,542			
Mobjack Bay	34	3,615			
Rappahannock River:					
Below Deep Creek	74	7,011			
From Deep Creek to Leedstown	142	2,218	3,263	27,164	3,859
Leedstown and above	56	618			
Potomac River:					
Below Mattox Creek	84	6,455	8	400	28
Above Mattox Creek	241	11,495	521	5,733	1,015
Total	2,028	77,058	9,378	90,214	10,949

Waters.	Drift nets.			Seines.		
	No.	Length.	Value.	No.	Length.	Value.
James River and tributaries:		*Yards.*			*Yards.*	
Below Chickahominy River				2	1,400	$730
Between Chickahominy and Appomattox rivers	225	69,727	$6,220	4	1,450	1,025
Above Appomattox River	128	11,020	1,535			
Chickahominy River	160	28,842	1,775	8	2,425	1,155
Appomattox River	46	6,720	388	5	1,225	475
York River and tributaries:						
York River				1	475	220
Pamunkey River	330	51,341	4,209	2	780	500
Mattaponi River	262	46,601	3,936	7	986	390
Rappahannock River:						
From Deep Creek to Leedstown	18	3,712	335	2	1,250	515
Leedstown and above	83	13,080	1,445	3	770	295
Potomac River:						
Above Mattox Creek	118	67,000	6,155	8	13,600	13,700
Total	1,370	298,043	25,998	42	24,361	19,005

Waters.	Pound nets.		Miscellaneous.		Shore property.	Total value.
	No.	Value.	No.	Value.		
Chesapeake Bay:						
Western shore	404	$116,118			$26,915	$170,878
Eastern shore	50	14,900			650	19,545
James River and tributaries:						
Below Chickahominy River	6	585			1,945	9,252
Between Chickahominy and Appomattox rivers					2,560	12,254
Above Appomattox River					700	2,845
Chickahominy River			[a] 3	$45	2,187	6,568
Appomattox River					650	1,878
York River and tributaries:						
York River	90	16,375	[b] 64	842	2,015	25,373
Pamunkey River					1,220	7,497
Mattaponi River					1,195	7,063
Mobjack Bay	76	15,570			1,640	20,825
Rappahannock River:						
Below Deep Creek	100	23,462			1,950	32,423
From Deep Creek to Leedstown	100	12,500	[b] 8	190	1,305	20,922
Leedstown and above	31	1,995	[c] 19	760	596	5,709
Potomac River:						
Below Mattox Creek	157	24,925			900	32,308
Above Mattox Creek	142	10,250			15,525	58,140
Total	1,156	236,680	94	1,837	61,953	433,480

a Hedges. *b* Fyke nets. *c* Fall traps.

Statement, by water areas, of the yield of shad in each form of apparatus employed in the fisheries of Virginia in 1896.

Waters.	Stake nets.		Drift nets.		Seines.	
	No.	Value.	No.	Value.	No.	Value.
Chesapeake Bay:						
Western shore	43,553	$6,230				
James River and tributaries:						
Below Chickahominy River	91,778	16,680			5,482	$480
Between Chickahominy and Appomattox rivers	9,928	1,644	162,655	$14,706	18,208	1,770
Above Appomattox River			33,385	2,709		
Chickahominy River			131,643	9,589	17,510	1,297
Appomattox River			11,945	1,087	8,309	794
York River and tributaries:						
York River	42,640	5,132			250	25
Pamunkey River	1,281	119	180,642	14,911	2,334	175
Mattaponi River			169,799	16,290	10,117	755
Rappahannock River:						
From Deep Creek to Leedstown	104,118	8,242	7,580	571	6,792	678
Leedstown and above			32,774	2,586	2,948	295
Potomac River:						
Below Mattox Creek	600	58				
Above Mattox Creek	10,910	1,558	142,400	11,729	79,385	6,471
Total	304,808	39,663	872,823	74,178	151,335	12,740

Waters.	Pound nets.		Miscellaneous.		Total.	
	No.	Value.	No.	Value.	No.	Value.
Chesapeake Bay:						
Western shore	1,071,841	$102,803			1,115,394	$109,033
Eastern shore	36,408	4,085			36,408	4,085
James River and tributaries:						
Below Chickahominy River	3,119	361			100,379	17,521
Between Chickahominy and Appomattox rivers					190,791	18,120
Above Appomattox River					33,385	2,709
Chickahominy River			a1,800	$130	150,953	11,016
Appomattox River					20,254	1,881
York River and tributaries:						
York River	138,895	12,890	b590	64	182,375	18,111
Pamunkey River					184,257	15,205
Mattaponi River					179,916	17,045
Mobjack Bay	140,777	13,874			140,777	13,874
Rappahannock River:						
Below Deep Creek	194,067	17,579			194,067	17,579
From Deep Creek to Leedstown	51,575	3,923	b1,015	75	171,080	13,489
Leedstown and above	16,862	1,414	c58	8	52,642	4,303
Potomac River:						
Below Mattox Creek	167,870	18,237			168,470	18,295
Above Mattox Creek	49,660	5,031			282,355	24,789
Total	1,871,074	180,197	3,463	277	3,203,503	307,055

a Hedges. *b* Fyke nets. *c* Fall traps.

CHESAPEAKE BAY IN VIRGINIA.

In Chesapeake Bay and tributaries are located the principal shad fisheries of America, the annual yield approximating 5,000,000 in number, 40 per cent of the product on the entire Atlantic coast. This large aggregation of shad, as well as many more of which we have no evidence, annually passes through the 12-mile entrance between Capes Charles and Henry, sending a detachment of 500,000 or more up James River, an equal quantity up the York, nearly as many up the Rappahannock, 1,250,000 in the meantime being caught on the shores of the bay below Smith Point, thus reducing the number to 2,250,000 by the time the mouth of the Potomac is reached. That river attracts about 750,000, leaving 1,500,000 to pass into the middle and upper waters of Chesapeake Bay and tributaries. Each of these water areas or river

basins and its fisheries will be separately described, leaving for the present a notice of that portion of the bay proper located in Virginia.

Shad appear to pass up this water-course mainly along the western shore, attracted, doubtless, by the fresh water from the large tributaries entering on that side, over 90 per cent of the total catch being obtained on that shore. If conditions are such that during the early season the waters of the rivers are warmer than those of the Chesapeake, large runs of shad occur up the rivers. But if rains and melting snows send down cold waters during April and May, then the shad remain longer in the bay and large catches are made there. In this section of the Chesapeake shad are taken almost exclusively by means of pound nets, this being the location of the most extensive pound-net fishery on the Atlantic coast. Within an area 70 miles long and 10 miles wide, covering the western side of the bay and the mouths of the tributaries from the James to the Potomac rivers, there were set in the spring of 1896 738 pound nets, worth $185,025, taking 1,638,593 shad, worth $156,950 at local prices. Of the above, 334 nets, taking 566,752 shad, were located in the mouths of the various rivers, leaving 404 nets, with a yield of 1,071,841 shad, as the number on the western shore of the bay proper.

In the limits of Princess Anne County two pound nets were set in Lynn Haven Roads, in 3 or 4 fathoms of water, one net being set off the head of the other. They were very large, the leaders being 327 fathoms in length, with 3¾-inch mesh, and the crib 50 by 60 feet with 2¼-inch mesh. Fishermen from Norfolk County set two small nets on Craney Island Flats, in Hampton Roads, a short distance west of Elizabeth River. Of the pound nets in Elizabeth City County, 11 were located between Newport News Point and Fort Monroe, and 62 between Fort Monroe and Black River, in from 10 to 18 feet of water. Although not strictly within the legal limits of those waters, it is advisable to list the pound nets between Poquosin Flats and York Spit as in York River, since shad taken in those nets have left the main body and are proceeding up the York. For the same reason those nets between York Spit and New Point are listed as in Mobjack Bay, and the 36 nets on the south side of Rappahannock Spit outside of a line drawn from Windmill Point to Stingray Point, the legal limit of Rappahannock River, are listed as within that stream.

On the shore of Mathews County, from New Point to Stingray Point, there were 93 nets set in from 10 to 24 feet of water. The remaining 234 pound nets on the west shore are located between Rappahannock Spit and Smith Point on the shores of Lancaster and Northumberland counties, in depths of water ranging from 12 to 40 feet. Pound nets are more numerous in this section than on any other portion of the Atlantic coast, there being 87 in 1896, in an area 6 miles long and 3 miles wide immediately below Smith Point. These nets were set mostly in strings of 6 or 7 each, but sometimes many more, one string having 16 nets. The mesh is generally 4¼-inch, but a few nets are constructed

with 2½-inch mesh for retaining alewives. The season extends from the first or second week of March to the end of May. The largest catch of shad in any one net was 12,130, obtained in the outer one of five set off Taskmaker Creek; while the smallest catch was 200 shad taken in a net set especially for alewives on the south side of Fleet Point.

On the eastern side of the Chesapeake 18 large pound nets situated on the shore of Northampton County and 32 on the shore of Accomack County, during the spring of 1896, caught a few shad. The catch by those nets in Northampton County is usually very small, and especially so in 1896, owing to the strong winds causing the fish to avoid that shore more than usual. The nets in Northampton County are set quite late, generally after the first week of April, when most of the shad have passed by. During some seasons shad are taken on this shore in considerable abundance. In 1885 2,600 were taken in one lift of a pound net, whereas in 1896 the same net yielded only 780 shad during the whole season. Of the 32 pound nets on the shore of Accomack County, 23 were set on Tangier Island and the remaining 9 on the east side of Pocomoke Sound. The season begins about March 20, and the last shad are taken about the end of June, the nets remaining in the waters until the end of September, catching quantities of bluefish, squeteague, Spanish mackerel, etc.

The following summary shows by counties the location and extent in 1896 of the pound-net fishery of that portion of the Chesapeake Bay located in Virginia, not including the nets operated in Mobjack Bay or at the mouths of York or Rappahannock rivers:

Counties.	Pound nets.		Boats.		Men.	Shad caught.	
	No.	Value.	No.	Value.	No.	No.	Value.
Western shore:							
Princess Anne	2	$2,500	1	$75	8	15,000	$2,300
Norfolk	2	500	2	75	2	7,500	800
Elizabeth City	73	20,975	101	2,525	105	163,722	17,541
Mathews	93	26,270	60	6,315	152	275,452	26,475
Lancaster	61	17,543	41	4,490	66	149,117	13,253
Northumberland	173	48,330	151	12,690	285	461,050	42,434
Eastern shore:							
Northampton	18	11,100	24	1,640	63	6,831	716
Accomack	32	3,800	33	2,355	46	29,577	3,369
Total	454	131,018	413	30,165	727	1,108,249	106,888

NOTE.—The Gloucester County pound nets located in York River and Mobjack Bay, and the Mathews County nets in Mobjack Bay, and the Lancaster County nets in Rappahannock River are not included in the foregoing.

MOBJACK BAY.

On the western side of the Virginia section of Chesapeake Bay there are 4 large coastal indentations which support important shad fisheries. Of these, 3 are estuaries of rivers, viz, James, York, and Potomac. The fourth, Mobjack Bay, receives the waters of a number of small streams, as Severn, Ware, North, and East rivers, yet it is a side elongation of Chesapeake Bay, 12 miles in length and 3 or 4 miles wide, with depth of water ranging from 18 to 25 feet.

Pound nets are the only apparatus used for taking shad, the number in 1896 being 76. Of these, 27 were located on the northeast side of the bay from New Point to the mouth of East River, and 49 on the southwest side between York Spit light and the mouth of Severn River, the nets on the north side of York Spit being listed as within this bay. These pound nets differed in no particular from those used in the Chesapeake, except that they were generally somewhat smaller, costing about $200 each. Shad were fairly abundant, but about the middle of March the fishing was injured by high winds, and the total catch for the year was less than usual, numbering 72,852 roe shad and 67,925 bucks. The fishermen of Mobjack Bay, as well as those of the Chesapeake, complain of the extremely low prices received, the local value of the 140,777 shad taken in this bay being only $13,874.

JAMES RIVER.

James River is formed by the junction of Jackson and Cowpasture rivers in Botetourt County and empties into Chesapeake Bay about 20 miles from the ocean, the entire river and all its tributaries lying wholly in Virginia. The total length, following its sinuosities, is about 335 miles, but in a straight line it is only 200 miles from the headwaters to the mouth. In the lower portion the width ranges from 2 to 6 miles, while from the entrance of the Chickahominy, 50 miles from the mouth, to the entrance of the Appomattox the average width of the river is less than 1 mile. At the entrance of the Appomattox the fluvial characteristics begin, and thence to Richmond the banks are quite steep and the course narrow and tortuous. The river is navigable for vessels drawing 16 feet to the head of tide water at Richmond, 111 miles distant from the mouth.

At Richmond there are numerous falls and rapids extending through a rocky bed a distance of 3 miles, in which the total descent is about 84 feet, and in these rapids there are several dams, supplying power to mills in Richmond and Manchester. These obstructions, however, do not entirely block the upward passage of shad, being low and extending only partly across the stream. Nine miles above Richmond is Bosher's dam, from 9 to 12 feet in height and 900 feet in length, entirely crossing the channel, forming a barrier to the further ascent of shad. If this dam were made passable, little benefit would be accomplished unless numerous other obstructions were similarly improved, there being 14 dams from 9 to 16 feet high within the 200 miles above Bosher's dam.

Prior to the erection of these obstructions large numbers of shad ascended as far as the junction of Jackson and Cowpasture rivers, and were taken in considerable quantities in those two tributaries over 335 miles from Chesapeake Bay. According to Marshall McDonald, the annual catch of shad between Richmond and Lynchburg was at one time far in excess of the present yield for the entire river, and even in the Valley of Virginia, west of the Blue Ridge, seine fisheries were

operated with profit. From April 1 to April 10, 1779, 2,200 shad were taken in one seine located at Wood Island, 100 miles above Richmond. At present few shad pass above the falls at Richmond, and practically none go higher than Bosher's dam.

The shad fisheries of James River are naturally divisible into three geographical sections, viz: (1) from the mouth of the river to the entrance of Chickahominy River, this portion being strictly an arm of the Chesapeake Bay; (2) from the Chickahominy to the entrance of Appomattox River at City Point, and (3) from the Appomattox to the foot of Bosher's dam, 9 miles above Richmond. Of the 324,555 shad taken in 1896, 100,379 were caught in the lower section, 190,791 between Chickahominy and the Appomattox, and 33,385 above the Appomattox.

The principal form of apparatus below the Chickahominy is the stake net, with an occasional pound net and seine. Between the Chickahominy and the Appomattox drift nets and seines are used, and thence to Richmond Falls the drift net is the only form of apparatus. In the falls there are a number of traps which take a few shad.

From Chesapeake Bay to Chickahominy River.—On the lower section of the James there were 84 strings of stake nets in 1896, each containing from 20 to 90 nets. The nets were each 30 feet long, from 40 to 70 meshes deep, with 5-inch mesh. The cost of the nets varies according to the depth of water in which set, but averages about $60 for a string of 50 nets, divided as follows:

Twine, 30 lbs. at 75 cents each	$22.50
Poles, 51 at 15 cents each	7.65
Skinning 51 poles at 7 cents each	3.57
Sticking 51 poles at 20 cents each	10.20
Hanging 50 nets at 11 cents each	5.50
Rings, 100 at 6 cents each	6.00
Rope, 50 lbs. at 10 cents each	5.00
Total	60.42

The strings of nets are set across the current on the sides of the channel in depths ranging from 8 to 18 feet. The season begins during the first week of March and ends about the last week of April. Fishing could be extended several weeks later, but on account of the low prices of shad and the deleterious effect of the warm water on the nets it is not generally profitable. Even with less than two months' fishing it is usually necessary to replace the nets at least once. In the 84 strings operated in 1896, containing 3,898 stations, there were used in all about 8,719 nets. The catch numbered 91,778 shad, of which 31,026, or 33.8 per cent, were bucks, the small proportion being due to the large mesh of the nets permitting them to pass through.

Just opposite Newport News, on either side of the channel, there were three small pound nets, worth about $100 each, which caught a few shad, the total yield being 3,119. These are the only pound nets used on the James, there being an interdiction against their use in this stream above Newport News.

Two seines were operated in 1896, one at Piney Grove in James City County, and the other at Swan Point in Surry County. These were

about 700 yards long, with 3-inch mesh in the bunt, and required the services of 9 men each. The season began May 12 and ended about the last of April, the catch of shad aggregating 5.482 in number, of which 4,355 were bucks.

From Chickahominy to Appomattox.—On the middle section of James River drift nets constitute the principal form of apparatus, yet a few seines are used, and in the extreme lower end there were 8 strings of stake nets in 1896. These strings, containing 235 nets, were operated by men living at Claremont and Sandy Point, taking 9,928 shad. The drift nets measure about 350 yards in length and 65 to 80 meshes deep, with 5-inch mesh. Where the channel is narrow, as from Coggins Point to City Point, this length is divided into two or three sections. On the shoal grounds between Coggins Point and City Point a number of shallow nets, 30 meshes deep, are used. These contain from 4 to 6 pounds of twine and are usually operated in two sections. Other than in depth they resemble in every particular the nets used in the channel. The total number of drift-net boats in the middle section of James River in 1896 was 182, using 69,727 yards of twine, and the catch of shad numbered 162,655, valued locally at $14,706.

Between the Chickahominy and the Appomattox there were formerly many seine beaches, most of which are now abandoned on account of the unprofitableness of the fishery and, in one or two cases, destruction of the beaches by engineering operations tending to improve the navigation of the river. In 1896 only four seine shores were operated, viz: Harrison Landing, Beechwood, Coggins Point, and Flowerdew Hundred. The seines were from 250 to 500 yards in length, with $2\frac{1}{2}$ and $2\frac{3}{4}$ inch mesh, and the yield of shad was 18,208, valued locally at $1,770. The large proportion of bucks in the catch of these seines is somewhat noticeable, numbering 13,385, or 73 per cent of the total yield, this being due doubtless to the large quantity of roes caught in gill nets in the lower part of the river.

From Appomattox to Bosher's Dam.—Above the entrance of Appomattox River drift nets are the only apparatus used in the James River shad fisheries. The principal fishing centers are Bermuda Hundred, Turkey Creek, and Deep Bottom, while a few nets are used above Dutch Gap, in Cox and Graveyard reaches. Formerly drift nets were used in Trent and Coal Yard reaches, situated in the loop of James River around Farrors Island, but since the opening of Dutch Gap that portion of the river has shoaled to such an extent that it is impracticable to drift in it. On account of the narrowness of the channel the nets above City Point are much shorter than those below, the length ranging from 40 to 100 yards. Usually two nets are operated by each boat, requiring the services of two men. The mesh is from $4\frac{7}{8}$ to $5\frac{1}{4}$ inches and the depth from 50 to 110 meshes. The season begins about the last week of March, three or four weeks later than at the mouth of the river, and closes about the end of May or first of June. In 1896 128 drift nets were used, the catch amounting to 33,385 shad, worth $2,709 at local valuation. Of this yield, 23,387, or 70 per cent, were bucks.

In the falls at Richmond there are numerous finger or fall traps, in which several hundred shad are taken annually while endeavoring to pass above the rapids. At one time the number of these fall traps exceeded 150, but the catch has been so small during recent years that the worn-out traps have not been replaced.

Chickahominy River.—The Chickahominy, one of the finest shad streams of the United States for its size, rises in Henrico County, 12 miles northwest of Richmond, and after flowing a distance of 60 miles empties into James River 50 miles from the Chesapeake Bay. Windsor Shades bar, 27 miles from its mouth, is the present head of navigation, a minimum depth of 8 feet existing to that point, the width of the channel ranging from 100 to 250 yards. Thence to Providence Forge, a distance of 5 miles, the channel is tortuous, 20 to 80 feet in width, flowing between low swampy banks, which open into lagoons or bays of wide water. From Providence Forge to Long Bridge, about 10 miles, the Chickahominy is a cypress swamp of from one-half to 1 mile in width, intersected by a channel 20 to 50 feet wide. Shad fisheries extend throughout the length of the Chickahominy, yet they are most extensive in the vicinity of Lanexa. The total catch of shad on this river in 1896 was 150,953, of which 131,643 were taken by means of drift nets, 17,510 by seines, and 1,800 by "hedgings." Of the total yield 103,748, or 68 per cent, were bucks.

In the lower portion of the Chickahominy and in the vicinity of Lanexa the drift nets contain each about 5½ pounds of No. 50 twine, 55 to 60 meshes deep, with 5-inch mesh. From Winns Landing to Providence Forge the nets contain from 1½ to 2 pounds of twine, 45 meshes deep, with 4⅞-inch mesh. The length of the 5½-pound net averages 200 yards, and of the 1¾-pound net 70 yards. The length of twine used by the 160 boats in 1896 measured 28,842 yards, one man being required for each boat. The season began about March 10 and closed some time near the middle of May. The yield was an average of recent years, aggregating 131,643 in number, of which 40,777 were roes and 90,866 were bucks. Eight seines were used in the Chickahominy during the same year, of which the largest, about 1,000 yards in length, was operated at Ferry Point, near the mouth of the river. This seine, however, is not used especially for taking shad, that species forming only a small proportion of the total catch. The lengths of the other seven seines range from 260 to 175 yards and the mesh from 1¾ to 2½ inches. The aggregate value of the 8 seines was $1,155, the number of men employed 43, while the total catch of shad numbered 17,510, worth $1,297 at the local valuation.

A short distance above Providence Forge, where the river is only a few feet in width, there are three or four hedges or pockets, each consisting of a crude dam, 2 or 3 feet high, permitting the passage of shad only through the current passing through an opening therein. A fisherman stands at this opening with a net in hand ready to lift out such fish as may attempt the passage. At the hedges operated in 1896 1,800 shad

were taken. The greater proportion of the fish caught by this method are either ripe or have already spawned.

Chickahominy River in the vicinity of Lanexa presents favorable conditions for the establishment of an auxiliary shad hatchery. Within a distance of 10 miles on either side of that station over 130,000 shad are taken annually, of which about 45,000 are roes. If 3 per cent of them are suitable for hatching purposes sufficient fertilized eggs would be secured to support an extensive hatchery. Large supplies could also be drawn from the James and the Pamunkey, each about 15 miles distant from Lanexa. The ripe fish could be obtained very cheaply and the shipping facilities are good, the main branch of the Chesapeake and Ohio Railroad passing along the river bank.

Appomattox River.—This river, the longest affluent of the James, rises in Appomattox County, Va., and after flowing about 140 miles empties into the James at City Point. Shad ascend only 13 miles to Petersburg, their progress above that city being barred by numerous rapids and dams. In a distance of 6¼ miles above the city there are 5 dams, each from 2½ to 8 feet high, and numerous falls and rapids, giving a total descent of 110 feet. Shad are taken in the Appomattox by means of drift nets and seines. The former are operated at Broadway, in Prince George County, and at Covington Beach or Cat Hole, in Chesterfield County, the total number of nets in 1896 being 46. These nets are from 100 to 200 yards in length, 45 to 70 meshes deep, with 5-inch mesh, and two men and one boat are required for each. The men live mostly in Petersburg, camping on the shores during the season, paying the owners for the privilege at the rate of one shad per week for each fisherman. The season begins the second week in March and continues about two months. The catch during 1896 was 3,835 roe shad, 8,110 bucks, with a local valuation of $1,087.

The seines used in Appomattox River were located as follows: One at City Point, one at Gatlin Beach, two at Covington Beach, and one at the mouth of Swift Creek. They measure from 200 to 275 yards each in length, about 80 meshes deep, with 2½-inch mesh. The shore rental paid for the five seines aggregates $225 annually. The season is coincident with that of the drift nets in the same locality, and the aggregate catch of shad in 1896 was 8,309, valued locally at $794.

In the falls of the Appomattox just above Petersburg there are about 20 fall or finger traps, in which a few shad are taken with herring and other species. The catch of shad is at present very much less than it was twenty years ago, probably not exceeding 50 in 1896.

YORK RIVER.

York River is formed by the junction of Pamunkey and Mattaponi rivers at West Point, and, following a southeasterly course for a distance of 41 miles, it unites with Chesapeake Bay about 16 miles north of Fort Monroe. It is really an arm of Chesapeake Bay, with an average width of about 1½ miles, possessing no fluvial characteristics

whatever. The water of York River is brackish nearly to West Point, oysters being planted within 6 miles of that town. Pound nets and stake nets represent the principal forms of apparatus used in the shad fisheries, and a few shad are taken incidentally in fyke nets and seines. The catch of shad in 1896 was 182,375, of which the pound nets yielded 138,895, stake nets 42,640, fyke nets 590, and seines 250.

Of the pound nets 53 were set on the north side of the river, between York Spit Light and Gloucester Point; 34 on the south side, near Toos Point and Poquosin Flats, and 3 near Plum Point, at the head of the river, making a total of 90 nets. Excepting the 3 near Plum Point and 23 on the shore of York County, all of these nets are owned in the southeastern portion of Gloucester County, mostly in the settlement known as Guinea. They range in value from $50 to $500, averaging about $200 each, and with some repairs will last for several seasons. The depth of water ranges from 10 to 20 feet, the leaders being set across the current. Each fishing company has from 1 to 7 nets, and uses sailboats averaging $100 in value, the total number of sailboats being about one-half the number of pound nets used. The season begins the first week in March and closes about the end of May, the greater part of the catch being obtained during April. Of 5,243 shad taken in 4 pound nets in 1896 1,262 were obtained in March, 3,170 in April, and 811 in May. The catch in 1896 was unusually small, the total yield of shad in the 90 pound nets being only 138,895, an average of 1,543 per net. The largest yield for any one net was 4,380. In addition to this species, the pound nets take alewives, Spanish mackerel, squeteague or sea trout, bluefish, croakers, pompano, etc.

The stake nets in York River are located on both sides of the channel from Cappahosack to West Point, but most abundantly between Potopotank Creek and Plum Point, being set in rows of from 10 to 20 nets in from 11 to 14 feet of water. The nets are 6 to 9 yards long, 35 meshes deep, with 5-inch mesh. They last only about three weeks, two settings being required for each season. The season begins about March 1, although most of the nets are not out until the middle of that month, and closes the third or fourth week of April. Nearly all of the fishermen are also farmers, and agricultural operations shorten the fishing season. In 1896 58 boats engaged in this fishery, using 990 stake nets, 6,461 yards in length, and the catch aggregated 28,232 roe shad, worth $3,949, and 14,408 bucks, worth $1,183. Except sufficient for local use, all the catch was sent to Baltimore by the steamers running between that port and West Point.

During the past season two fishermen from Indiantown, on the Pamunkey River, attempted to take shad with drift nets in the narrow portion of York River between Gloucester Point and Yorktown, where the width is a trifle over a half mile. Their nets were 200 yards long, 65 meshes deep, with 5-inch mesh. After working about ten days without success they abandoned their attempt. It should be noted that the depth of water in this portion of York River is 80 feet or more, whereas the nets used were only about 15 feet deep.

Pamunkey River.—This river, which takes its name from a tribe of Indians, the remnant of which is yet engaged in shad fishing in its waters, is formed by the junction of the North Anna and South Anna rivers a short distance above Hanover Court-House, whence it flows a distance of 100 miles to its union with the Mattaponi at West Point. It is navigable, during eight or nine months of the year, for vessels drawing 5 or 6 feet of water, as far as Wormley Landing, 54 miles above West Point. Above Wormley Landing the river is tortuous, much obstructed by logs and brush, and from 40 to 120 feet wide. Shad ascend the Pamunkey in considerable numbers throughout its length, but are taken in greatest abundance in the lower 30 miles. Of the 184,257 shad caught in 1896 180,642 were taken by means of drift nets, 2,334 by seines, and 1,281 in stake nets.

The drift nets are operated throughout a distance of 43 miles from the mouth of the river, and principally for a distance of 10 miles below and the same distance above Lester Manor, 24 miles from York River. The drift nets below Williams Ferry average 150 yards in length, 55 to 70 meshes deep, with 4¾ or 5 inch mesh. Above Williams Ferry the length ranges from 130 to 75 yards and the depth from 50 to 35 meshes. Below Williams Ferry two or three nets are carried by each boat, requiring the services of two men. Above that point, where the fishing is for local use exclusively, each boat has but one net, and in some instances but one man. When more than two nets are used the extra nets are old ones, which can be used only during weak tide or slack water. A total of 330 nets, 51,341 yards in length, were used by the 153 boats in 1896, the catch numbering 180,642 shad, for which the fishermen received $14,911. Below White House the season begins during the first week of March and closes some time in May, depending on the run of fish and the market price. At some landings the sturgeon fishery or agricultural operations shorten the season. Above Williams Ferry the season begins during the third and fourth week of March and closes about the 10th or 15th of May.

Several rows of stake nets are set in the extreme lower end of the Pamunkey during March and April. These are similar to the nets in the upper portion of York River, and their catch in 1896 was only 1,281 shad. There were two seines operating in this river during the past year, one at Smith Ferry and the other at Sweet Hall, distant 21 and 24½ miles respectively from the mouth of the river. The former was distinctively a shad seine, while the latter was used also for alewives, striped bass, etc. The yield of shad by the two seines was 2,334, of which 1,490 were bucks. Very few were taken in the upper one of these seines, it being shoal, and during the work of deepening it the shad passed by. In the narrows of the Pamunkey, near Hanover Court-House, there are several "hedgings," which take a few shad each year, probably not exceeding 500. It does not appear that shad pass above Hanover Court-House in any considerable numbers, and probably none are taken in South Anna and North Anna rivers.

There are few places south of Potomac River better adapted to shad-hatching operations than the Pamunkey between Hill's Landing and White House Station. Within a river length of 16 miles, the distance in a straight line approximating 6 miles, there were in 1896 109 drift-net boats, taking 154,072 shad, and two seines taking 2,334 shad, a total of 156,406. Of these 70,383, or 45 per cent, were roe shad, of which about 14,000 were taken after April 20. It is reported that 10 per cent of the roe shad taken after April 20 are suitable for fertilization, making a total of 1,400 that may be used for this purpose. This does not include the ripe fish that may be obtained prior to April 20, nor the number that may be drawn from the Mattaponi, 6 to 8 miles distant, or the Chickahominy, within 15 miles, each of which would yield nearly, if not quite, as many as the Pamunkey. This section of the stream is bordered by the West Point branch of the Southern Railway, giving convenient shipping facilities.

Mattaponi River.—The Mattaponi rises in Spottsylvania County, and after flowing a distance of over 120 miles unites with Pamunkey River at the head of York River. The lower 60 miles from the mouth to Aylett is navigable and has considerable traffic. From Aylett to Mundy's Bridge, a distance of 26 miles, the channel is obstructed by logs, drift, and overhanging trees, yet it is navigated by rafts and small boats. The Mattaponi is not quite so large or so deep as the Pamunkey, but is otherwise quite similar, and there is even less difference in the extent and characteristics of the shad fisheries of the two streams. As on the Pamunkey, drift nets and haul seines are the means of capture, the yield by the former apparatus being by far the greater.

The drift nets are similar in every particular to those used on Pamunkey River, except that they are somewhat longer, with a smaller number to each boat, the length of the 262 nets on this stream in 1896 aggregating 46,601 yards. The total catch by the 153 boats numbered 169,799, valued locally at $16,290. While a large portion of this catch is sold locally, most of it is sent by boat or hauled across land to the West Point branch of the Southern Railway, and thence shipped to Richmond and other distant markets.

The seven haul seines on the Mattaponi were used at the following points: Savage's, Walkerton (2 seines), Gathney's, Bugley's, and Jones Landing in King and Queen County, and at Pointer Landing in King William County. They range in length from 280 yards to 50 yards, the mesh being 2½ inches. The season begins generally during the first week of April and extends to about the end of May; but at Savage, 16 miles above West Point, the season is somewhat earlier than this. The total catch by the above seven seines was 10,117 shad, the smallest for a number of years. There were formerly several small seines above Pointer Landing, as well as at other places on the Mattaponi, but they have given way to the cheaper and more effective drift nets.

RAPPAHANNOCK RIVER.

This river rises on the eastern slope of Blue Ridge Mountains, in Fauquier and Rappahannock counties, and crosses the fall line at Fredericksburg, the head of navigation, 106 miles from its mouth, following the course of the river. The fluvial characteristics extend only about 40 miles below the fall line and the lower 50 miles is really an arm of Chesapeake Bay. About 2 miles above Fredericksburg there is a dam 900 feet long and 18 feet high, built in 1860 and used for developing water-power, which completely blocks the upward passage of fish.

In describing the shad fisheries of the Rappahannock, the river is naturally divisible into three sections: (1) from the mouth to Deep Creek, the boundary line between Lancaster and Richmond counties, 26 miles; (2) from Deep Creek to the boundary line between Westmoreland and King George counties, 45 miles; (3) thence to Fredericksburg, 36 miles.

From Chesapeake Bay to Deep Creek.—The lowest of these three sections is purely an arm of the Chesapeake, the width ranging from 4 to $2\frac{1}{4}$ miles. Pound nets, which constitute the only form of apparatus used for taking shad, were introduced in this locality in 1872, and their use has increased each year, the number employed in 1896 being an even 100, valued at $23,462. Fifty-seven of these were located at the extreme end of the north side of the river between Windmill Point Light and Windmill Point Creek, the depth of water ranging from 10 to 25 feet. The remaining 43 nets were located as follows: Twelve between Mosquito Point and the mouth of Corrotoman River, and 12 between the Corrotoman and Deep Creek on the north side; and on the south side, 8 near the mouth of the river and 11 between Urbanna Creek and Parrott Creek. The difference in the number of nets set on the north and south side of the river—81 and 19 respectively—is quite remarkable, due to the rough water and fewer fish on the south side.

The mesh in the heart of the pound nets is generally $4\frac{1}{4}$ inches, but a few of the nets have $2\frac{1}{2}$-inch mesh, for retaining alewives also. The latter species are so cheap, however, that very few fishermen in this region bother with them. Each pound-net company has from 2 to 7 nets, requiring the services of an equal or greater number of men, and one or two sailboats, worth from $50 to $400 each, and one or two rowboats. The total number of men engaged in operating the 100 pound nets was 116, using 43 sailboats, valued at $6,321, and 31 rowboats, worth $690.

The season began during the last week of March and closed about the first of June, the greater portion of the catch being obtained from April 10 to May 10. The total catch was 194,067 shad, valued locally at $17,579. Of these, 46 per cent were roe shad and 54 per cent bucks. The pound nets also caught about 500,000 alewives and quantities of squeteague, bluefish, sturgeon, etc.

Except such as are sold locally the yield of shad in the pound nets,

as well as in other apparatus set in the Rappahannock, is sent to Baltimore by the daily steamers serving that river.

From Deep Creek to Layton.—In the second of the three sections of Rappahannock River, covering Essex, Richmond, and Westmoreland counties, the forms of apparatus used are stake nets, pound nets, drift nets, seines, and fyke nets. The total catch of shad in 1896 was 171,080, valued locally at $13,489, of which 104,118 were taken in stake nets, 51,575 in pound nets, 7,580 in drift nets, 6,792 in seines, and 1,015 in fyke nets.

The pound nets in this section are much smaller than those near the mouth of the river, averaging in value $125 each against $235 near the mouth. They are usually set singly, but occasionally two and even three are set in one string, especially between Sharp's wharf and Tappahannock. Along the northeast side of the river there were 63 pound nets, 52 on the shore of Richmond County and 11 on the Westmoreland shore. On the opposite side—the Essex County shore—there were 37 pound nets, making an even 100 nets for this section of the Rappahannock. The catch was smaller than for several years preceding. Three pound nets set near Sharp's wharf caught 4,442 shad in 1895 and 3,872 in 1896, 764 of the latter being obtained in one day. The total yield in 1896 was 51,575, valued at $3,923, 38 per cent of these being roes.

All the stake nets on Rappahannock River are located in this section, and they extend throughout the 38 miles from Deep Creek to Leedstown. They are 8 or 9 yards long, 10 to 20 feet deep, with 4½ to 5 inch mesh, of linen twine, and must be renewed each season, if not more frequently. They are set in strings of 10 to 30 nets on the sides of the channel at intervals of a few hundred feet. The total number in use in 1896 was 3,263, aggregating 27,164 yards in length, the yield of shad numbering 104,118, valued locally at $8,242. The stake-net season began about March 20 and ended the last of April, the greater portion of the yield being obtained during the first two weeks of April. Comparing the stake-net fishery of the Rappahannock with that of James River, it appears that the yield in the latter stream was 101,706 shad, or 2,412 less than in the former. But the value of the catch in the James was $18,524, over twice that of the Rappahannock, the difference being due principally to the season in the James being nearly three weeks earlier than in the latter stream.

The drift nets in the middle section of Rappahannock River are operated in the extreme upper end thereof above Leedstown. They average over 200 yards in length, 5-inch mesh, 60 meshes deep, and cost about $20 each, 2 nets being used by each boat, which requires the services of 2 men. The season extends from the last week in March to the first of May. The catch of the 9 drift-net boats in 1896 was 7,580 shad, worth locally $571, of which 40 per cent were roes, the percentage being greater than for several years preceding.

Two shad seines were used on the shore of Essex County, one at Mallory Point and the other at Port Tobacco, at distances of 46 and 71

miles, respectively, from the mouth of the river. These seines were 450 and 800 yards long, respectively, with 2 and 2½ inch mesh, and required the services of 6 or 7 men each. The season extended from the last week of March to the end of May, and at the lower beach 815 shad were taken, of which 585 were bucks, while at the upper one the yield of shad was 5,977, of which 3,791 were bucks. Both of these seines are also used throughout the year for taking other fish. Prior to 1885 a hatchery was operated on the opposite side of the river from the Port Tobacco seine, utilizing the eggs therefrom.

A few shad are taken during March and April in the fyke nets set near Tappahannock. Eight nets were used in 1896 worth $190, and the yield of shad numbered 1,015, of which 460 were roes and 555 bucks.

From Tobago Bay to Fredericksburg.—The upper end of the navigable portion of Rappahannock River consists of a tortuous stream, 36 miles in length, 50 to 250 yards wide in its upper 28 miles, broadening out at its lower end, and terminating in two small bays—Nanzatico and Tobago—a mile or more across. The counties bordering this section are King George, Caroline, Stafford, and Spottsylvania. Drift nets, pound nets, and seines are used for taking shad, and at the extreme upper limit, in Falmouth Falls above Fredericksburg, there are several fall or finger traps. The drift nets and pound nets are used from Tobago Bay to Hop Yard, the lower 17 miles, and the seines are used at the two extremities. Of the 52,642 shad obtained in 1896, 32,774 were caught by drift nets, 16,862 by pound nets, 2,948 by seines, and 58 by fall traps.

The drift nets measure from 75 to 100 yards in length, 30 to 52 meshes deep, with 5-inch mesh, and cost from $12 to $20 each. Near Port Royal the season begins about the second or third week of March and lasts about two months. In the short drifts, fishing is prosecuted only during slack water. When the water is clear fishing is restricted to the night time, but when it is muddy the fishermen operate mostly during the day. Of the 32,774 shad taken by these nets in 1896, 19,941, or 61 per cent, were bucks.

The pound nets in the upper section are very small, averaging about $65 in value each. Excepting two strings just below Oaken Brow, one containing 4 and the other 3 nets, all of the pound nets are set singly. An average of $10 is paid for shore rental for each net. The season extends throughout the months of April and May, and about 5 per cent of the catch is reported as being ripe roe shad. The total catch of shad by the 31 pound nets numbered 16,862, valued locally at $1,414, of which 6,285 were roes.

A 500-yard seine, with 2½-inch mesh and 8 feet deep, was operated on the upper side of Tobago Bay in 1896, taking 2,892 shad from March 20 to May 20. In addition to this seine there were two others, 150 yards in length each, with 2½-inch mesh and 6 feet deep, operated on the Stafford County shore, opposite Fredericksburg. Very few shad were taken in these two seines, the total number being 56, of which 49 were bucks.

In the falls of the Rappahannock above Fredericksburg and adjacent to Falmouth there are 19 fall or finger traps, which take many alewives and a few shad, the number of the latter in 1896 approximating 58, of which 38 were bucks. There are no shad whatever reported from this stream above Falmouth Falls.

POTOMAC RIVER.

Although the Potomac River forms the boundary line between Virginia and Maryland, it is located wholly within the limits of the latter State. By a compact made in 1785 a right of fishery in this river exists in common between citizens of the two States, citizens of Virginia enjoying equal privileges with those of Maryland. This makes it convenient to describe the shad fisheries of both sides of the river at the same time, and as the river is situated wholly in the limits of Maryland, this discussion is placed in the chapter on the shad fisheries of that State (page 199). It will suffice to note in this place that the yield of shad on the Potomac during 1896 numbered 684,063, of which 450,825, worth $43,084, were taken by residents of Virginia.

THE SHAD FISHERIES OF MARYLAND.

The extent, by water areas, of each branch of the shad fisheries of Maryland in 1896 is presented in the following series of three tables, showing (1) the number of persons employed, (2) the boats, apparatus, etc., used, and (3) the number and value of shad taken.

Statement, by water areas, of the number of men employed in each branch of the shad fisheries of Maryland in 1896.

Waters.	Number of fishermen.						Total, exclusive of duplication.	Shoresmen.	Transporters.	Total.
	Gill-net.		Seine.	Pound-net.	Fyke-net.	Bow or dip-net.				
	Drift.	Stake.								
Chesapeake Bay:										
Below Swan Point—										
Eastern Shore		64		27			91			91
Western Shore				76			76			76
Above Swan Point—										
Eastern Shore	310	101	110	37			548	24		572
Western Shore	206		206	8			420	247	13	680
Potomac River	241		87	116		25	469	39	4	512
Patuxent River	19		47	24			90			90
Pocomoke River	36		24		4	191	253			253
Wicomico River	180	19	20	6	9		230			230
Nanticoke River	146	32		20	26		210			210
Marshyhope Creek	76		40	9			125			125
Fishing Bay		21		5			23			23
Transquaking River				24		40	64			64
Blackwater River	36			27			62			62
Choptank River	236	68	71	135	6		490			490
Tuckahoe Creek	75		44	8	6		127			127
St. Michael River		60					60			60
Chester River	4	109	65	61	33		266			266
Sassafras River				21			21			21
Elk River				85			85			85
Susquehanna River	98		295		a9	8	406	71		477
Total	1,663	474	1,009	689	93	264	4,116	381	17	4,514

a Fall-trap.

Statement, by water areas, of the boats, apparatus, etc., employed in the shad fisheries of Maryland in 1896.

Waters.	Boats.		Drift nets.			Stake nets.			Pound nets.	
	No.	Value.	No.	Length.	Value.	No.	Length.	Value.	No.	Value.
Chesapeake Bay:										
Below Swan Point—				*Yards.*			*Yards.*			
Eastern Shore	53	$1,530				154	5,580	$616	22	$4,215
Western Shore	41	3,570							86	11,224
Above Swan Point—										
Eastern Shore	191	10,938	433	138,680	$11,154	1,322	32,900	3,745	63	3,885
Western Shore	186	38,410	654	110,350	9,925				6	900
Potomac River	195	6,945	118	94,500	6,230				131	8,175
Patuxent River	43	975	18	1,205	185				33	4,116
Pocomoke River	126	729	40	2,180	322					
Wicomico River	194	1,470	307	20,040	2,884	70	1,400	290	5	470
Nanticoke River	109	2,459	151	22,429	3,376	282	3,788	684	26	2,635
Marshyhope Creek	51	485	75	7,160	912				12	380
Fishing Bay	16	890				388	6,930	459	4	260
Transquaking River	42	590							*a* 29	1,495
Blackwater River	53	490	46	1,840	184				39	1,575
Choptank River	244	3,981	454	35,990	4,704	1,469	23,280	2,500	185	11,851
Tuckahoe Creek	57	659	117	8,802	1,140				9	290
St. Michael River	31	555				92	3,690	275		
Chester River	141	2,718	2	290	45	178	7,020	963	*b* 81	5,515
Sassafras River	14	340							*b* 31	1,810
Elk River	41	2,268							*b*139	8,020
Susquehanna River	148	24,490	223	28,672	3,403					
Total	1,976	104,492	2,638	472,138	44,464	3,955	84,588	9,532	901	66,816

Waters.	Seines.			Fyke nets.		Bow nets.		Shore property.	Total value.
	No.	Length.	Value.	No.	Value.	No.	Value.		
Chesapeake Bay:									
Below Swan Point—		*Yards.*							
Eastern Shore								$860	$7,221
Western Shore								925	15,719
Above Swan Point—									
Eastern Shore	2	4,700	$3,300					4,130	37,152
Western Shore	5	7,500	7,100					17,575	73,910
Potomac River	5	3,640	4,000			3	$6	5,100	30,456
Patuxent River	10	1,700	1,815					653	7,744
Pocomoke River	6	462	194	16	$204	97	505	871	2,825
Wicomico River	3	630	330	36	399			1,844	7,687
Nanticoke River				143	2,495			1,105	12,754
Marshyhope Creek	8	545	410					2,970	5,157
Fishing Bay								85	1,694
Transquaking River						20	90	80	2,255
Blackwater River								130	2,379
Choptank River	14	3,293	1,460	23	236			7,148	31,880
Tuckahoe Creek	8	1,244	900	34	314			3,940	7,243
St. Michael River								80	910
Chester River	17	3,835	1,307	83	1,575			1,050	13,173
Sassafras River								315	2,465
Elk River								710	10,998
Susquehanna River	12	5,800	5,000	*c*15	600	8	24	3,953	37,470
Total	90	33,349	25,816	*c*15 335	600 5,223	128	625	53,524	311,092

a Includes 12 "stick weirs." *b* Not set specially for shad, and some catch very few of that species. *c* Fall traps or pots.

Statement, by water areas, of the yield of shad in each form of apparatus employed in the fisheries of Maryland in 1896.

Waters.	Drift nets.		Stake nets.		Seines.		Pound nets.	
	No.	Value.	No.	Value.	No.	Value.	No.	Value.
Chesapeake Bay:								
Below Swan Point—								
Eastern Shore			4,620	$786			25,160	$3,570
Western Shore							134,119	18,347
Above Swan Point—								
Eastern Shore	133,480	$12,210	36,779	2,974	16,480	$1,895	7,595	825
Western Shore	109,423	11,761			17,142	2,169	2,244	274
Potomac River	136,880	11,459			44,060	3,382	51,698	5,533
Patuxent River	19,700	2,277			24,375	2,680	8,279	910
Pocomoke River	3,198	491			2,537	365		
Wicomico River	45,398	5,442	4,725	734	4,054	452	12,536	1,667
Nanticoke River	62,876	5,816	17,665	2,015			35,303	3,022
Marshyhope Creek	24,920	2,366			7,180	823	6,560	676
Fishing Bay			8,165	991			1,625	183
Transquaking River							12,094	1,133
Blackwater River	3,700	429					9,460	1,051
Choptank River	80,591	8,541	35,275	3,813	45,050	5,183	114,758	11,811
Tuckahoe Creek	39,670	4,084			22,195	2,295	283	27
St. Michael River			2,215	423				
Chester River	275	50	19,590	3,223	9,933	1,526	21,319	2,826
Sassafras River							1,290	166
Elk River							5,244	637
Susquehanna River	35,540	3,949			30,345	3,729		
Total	695,651	68,875	129,034	14,959	223,351	24,499	449,567	52,658

Waters.	Fyke nets.		Bow nets.		Total.	
	No.	Value.	No.	Value.	No.	Value.
Chesapeake Bay:						
Below Swan Point—						
Eastern Shore					29,780	$4,356
Western Shore					134,119	18,347
Above Swan Point—						
Eastern Shore					194,334	17,904
Western Shore					128,809	14,204
Potomac River			600	$150	233,238	20,524
Patuxent River					52,354	5,867
Pocomoke River	205	$32	23,812	3,416	29,752	4,304
Wicomico River	1,302	185			68,015	8,480
Nanticoke River	9,337	795			125,181	11,648
Marshyhope Creek					38,660	3,865
Fishing Bay					9,790	1,174
Transquaking River			1,600	154	13,694	1,287
Blackwater River					13,160	1,480
Choptank River	402	38			276,076	29,386
Tuckahoe River	196	18			62,344	6,424
St. Michael River					2,215	423
Chester River	2,390	293			53,507	7,918
Sassafras River					1,290	166
Elk River					5,244	637
Susquehanna River	*a*2,003	259	1,600	220	69,488	8,157
Total	15,835	1,620	27,612	3,940	1,541,050	166,551

a Fall traps or pots.

CHESAPEAKE BAY IN MARYLAND.

Chesapeake Bay extends northward into the State of Maryland a distance of 120 miles, running to within 12 miles of the northern boundary, dividing the State into two large portions, the Eastern Shore and Western Shore. It is from 4 to 20 miles wide and covers an area of 976 square miles, but, including its numerous tributaries up to the limit of tide water, it covers an area of 2,359 square miles within Maryland limits. The depth is from 3 to 18 fathoms, and the water is salty, except in the northern portion above Swan Point, where it becomes

somewhat brackish. A number of important rivers enter this bay from either side, and Susquehanna River enters at the northern end, continuing the separation of the two shores of Maryland and draining a large area of Pennsylvania.

At its entrance into Maryland, Chesapeake Bay receives each year 2,250,000 or more shad, of which about 750,000 pass up the Potomac, 330,000 proceed up the Pocomoke and Tangier Sound tributaries, 50,000 up the Patuxent, 350,000 up the Choptank and tributaries, 50,000 up the Chester, 650,000 in the meantime being taken on the shore of the Chesapeake and its smaller tributaries, leaving 70,000 or more to pass up into the Susquehanna. These figures include only the shad that are taken by the fishermen, and not those otherwise destroyed or that escape these fatalities and return to the sea, as to the number of which no estimate can be formed. The shad fisheries of each of the several tributaries of the Chesapeake will be separately described, leaving for the present chapter a notice of the fisheries of the bay proper. Many of the shad obtained in the bay are taken in the lower and middle portions, but the great bulk of the catch is taken in the extreme upper end.

Because of the differences in the physical characteristics, in the forms of apparatus used, and also in the seasons at which shad are taken therein, it is desirable in treating of the Chesapeake fisheries to separate them into two geographical sections, the first covering the lower three-fourths or more of the bay, from the Virginia line to Swan Point, and the second including that part above Swan Point, which is at the north side of the mouth of Chester River and opposite Patapsco River.

From the Virginia line to Swan Point.—This portion of Chesapeake Bay is 90 miles long and from 4 to 20 miles wide. From the western side it receives the waters of the Potomac and Patuxent rivers, while from the east it receives the Pocomoke, Wicomico, Nanticoke, Choptank, and Chester rivers, and some smaller streams.

The shad fisheries outside of the rivers are of comparatively small extent and confined to the use of pound nets and a few stake nets, yielding 159,279 and 4,620, respectively, in 1896, of which 29,780 were obtained by men living on the Eastern Shore and 134,119 by fishermen from the Western Shore.

The location of pound nets on the Eastern Shore was as follows: Pocomoke Sound, 8 nets, taking 7,149 shad; below Little Annemessex River, 5 nets, yielding 1,416 shad; Smith's Island, 1 net taking 4,875 shad; Tilghman Island and Wittman, 4 nets, with 2,640 shad; and Kent Island, 4 pound nets, yielding 9,080 shad. On the Western Shore 4 nets were located at Point No Point, 29 near the mouth of the Patuxent, 5 at Governor Run, and 48 between Holland Point and Gibson Island, making a total of 86 nets, worth $11,224, which yielded 53,167 roe and 80,952 buck shad, worth $18,347. Most of the pound nets are of the "single heart" variety, and the mesh in the bowl is generally 4 inches,

but some have 2½-inch mesh for retaining alewives. The season for shad begins the second or third week of March and continues for nearly two months. The yield at the various stations was much less in 1896 than in 1895 and several previous years. In the 5 nets set just below the mouth of Little Annemessex River only 1,416 shad were taken in 1896, whereas in 1893 2,100 shad were obtained in one lift of the same nets. The decrease was not confined to shad, but shared in by nearly all the species usually taken. In the spring of 1895 the 5 nets above referred to yielded $3,400 worth of fish, while the local value of the catch in the spring of 1896 did not exceed $600.

The stake nets are located along the shore from Tilghman Island to Kent Island. In 1896, 96 nets were set on the shore of Tilghman Island, 27 off Sherwood and Wittman, and 31 along the shore of Kent Island, making a total of 154 nets. The number of men employed was 64, and the catch numbered 3,300 roe and 1,320 buck shad, valued locally at $786. This fishery is almost entirely for local use, and comparatively few of the shad thus taken find their way into distant markets.

From Swan Point to head of Chesapeake Bay.—This section of the Chesapeake, comprising less than one-fourth of the area of the bay proper, is bordered on the east by Kent and Cecil counties and on the west by Baltimore and Harford counties. The depth of water in the channel ranges from 3 to 5 fathoms, yet there are numerous shoals and flats where the depth is from 2 fathoms to a few inches. The water is normally brackish, but during heavy freshets it becomes almost fresh above Spesutie Island. Susquehanna River enters the extreme northern end, and on the northeast three arms extend several miles inland, forming the estuaries of Northeast, Elk, and Sassafras rivers. The principal fishing centers are Havre de Grace on the Western Shore, and Charlestown, Northeast, Betterton, Tolchester, and Rock Hall on the Eastern Shore. This is the principal shad region of Chesapeake Bay, as determined by both the quantity and quality of the product. The yield in 1896, although smaller than usual, numbered 130,011 roes and 193,132 bucks, of which 87,875 roes and 155,028 bucks were taken by drift nets, 23,524 roes and 13,255 bucks by stake nets, 15,040 roes and 18,582 bucks by seines, and 3,572 roes and 6,267 bucks by pound nets, the total local value of the whole being $32,108.

This is the location of the most valuable drift-net fishery of the Atlantic coast south of Delaware Bay. The nets are operated from the mouth of the Susquehanna down to Poole Island, a distance of 25 miles, and at times even below that point. They are also operated in that arm of the Chesapeake known as North East River and in the extreme lower ends of Elk and Sassafras rivers. The depth of water in which they are drifted ranges all the way from 3 or 4 to 30 feet, but most of the nets are designed for use in 14 to 18 feet of water. From 400 to 2,000 yards of twine are carried by each boat, the total for the 191 boats operating in 1896 being 249,030 yards. This is usually cut

into lengths containing from 150 to 400 yards each. The size of the mesh is mostly 5¼ inches, but some fishermen use 5⅛, 5⅜, and 5½ inch. The cost of 1,000 yards medium-width twine is about \$85. Two or three men are required for each boat, the value of the latter averaging nearly \$100 each. The nets are used principally at night, a lantern mounted on a float being attached to each end. While the nets are drifting the fishermen "run" the net from end to end, discovering the presence of fish by the "feel" of the upper line. That portion of the net containing the fish is then raised and the shad removed, when the net is dropped to drift as before.

It is essential that the fish be removed very soon after they are enmeshed, otherwise they are likely to be mutilated by eels, which are very annoying during the shad season. Sometimes a large part of the catch is found to consist of heads and backbones of shad, from which the flesh has been stripped by eels.

The season begins about the 1st of April and extends to the last of May or 1st of June. The catch in 1896 was unusually small, the total yield for the 191 boats being only 242,903, an average of 1,272 per boat. Some boats have caught over 8,000 shad in one season. The catch by drift nets has been decreasing for several years, attributed by the fishermen to the increased number of pound nets in the Virginia section of Chesapeake Bay. The following summary shows the location and extent of the drift-net fishery in this part of the Chesapeake in 1896:

Residence of fishermen.	Men.	Boats.		Drift nets.		Shad caught.		
	No.	No.	Value.	Length.	Value.	No. of roes.	No. of bucks.	Value.
Kent County:				*Yards.*				
Rock Hall	44	17	\$440	18,720	\$1,720	9,860	10,310	\$1,775
Harris Wharf	38	13	1,290	15,680	1,470	5,690	8,325	984
Betterton	44	16	1,545	21,760	1,924	8,340	12,535	1,597
Cecil County:								
Chesapeake City	15	5	305	6,420	565	3,250	5,670	842
Elkton	12	4	210	5,430	510	3,120	5,760	630
Northeast and Elk Neck	106	36	1,460	46,800	2,980	14,880	25,310	4,355
Charlestown	51	17	690	23,870	1,985	5,620	14,810	2,027
Harford County:								
Havre de Grace	175	70	10,170	94,950	8,400	32,523	65,049	10,328
Aberdeen and Perryman	10	4	600	4,800	480	1,374	2,139	446
Michaelsville	10	4	600	4,800	480	1,226	1,842	392
Abingdon and Edgewood	8	4	400	4,400	440	1,542	2,828	514
Baltimore County:								
Chase	3	1	140	1,400	125	450	450	81
Total	516	191	17,850	249,030	21,079	87,875	155,028	23,971

Twenty-five years ago stake nets were extensively operated in this portion of Chesapeake Bay, but they have gradually given way to the more effective and less costly drift nets. They are yet operated along the shore of Kent County between Swan Point and Worton Point, and especially on the flats off Tolchester Beach, the fishermen living on Kent County shore. The nets are about 25 yards in length and 45 meshes deep, with 5⅛ or 5½ inch mesh, and are set in rows in from 10 to 18 feet of water, 20 to 40 nets being used by each boat. In 1896 there were 101 men engaged in the stake-net fishery, using 1,322 nets, 32,900

yards long, worth $3,745. The nets were set about February 1 for striped bass, and the season for taking shad extended from March 20 to the beginning of May, the yield numbering 23,524 roes and 13,255 bucks, valued locally at $2,974. The price during that season was unusually small, the lowest certainly within the last ten years.

Six seines were used in the extreme northern end of Chesapeake Bay in 1896, their location being as follows: Carrot Cove (1 seine), Carpenter Point (1 seine), Fishing Battery Light (2 seines), and Spesutie Island (2 seines). The length ranges from 1,500 to 2,500 yards, the aggregate of the 6 seines being 11,600 yards, with 2 to 3 inch mesh. The value of the 6 seines was $10,200, and the number of fishermen employed 306, with 268 shoresmen. The season began the second week of April and lasted six or seven weeks, the catch numbering 14,560 roes and 18,052 bucks, worth $3,902. The yield of alewives numbered 6,516,000. In addition to the above, there was one seine on Miller Island used for taking striped bass and perch, in which some shad were caught. This seine was 600 yards in length, required 10 men to operate it, and the catch of shad numbered 480 roes and 530 bucks. Large quantities of alewives were obtained, but on account of the low prices ruling for these fish very few of them were marketed.

The two seines at the Fishing Battery Light are operated from large floats or batteries, containing stables, storehouses, salting sheds, quarters for the men, etc. An average float is simply a large raft, 60 by 80 feet, of sufficient buoyancy to be removed to any desirable point on the flats, where it is secured into position by piles passing through wells in the raft. Each of three sides of the float is provided with an apron 45 feet wide, held in position by stout chains, and which can be raised or lowered at will. This apron provides an inclined plane, on which the seine is hauled in the same manner as at shore seines. The selection of the side on which the hauling is made is determined by the direction of the current, the wind, etc. The fourth side is used as a wharf. When practicable three hauls are usually made each day, two on the ebb tides and one on a flood tide, the yield of shad on the former being five or six times as great as the latter.

Of the 69 pound nets operated in the upper portion of Chesapeake Bay in 1896, 46 were located between Turkey Point and Northeast, 7 between Charlestown and Carpenter Point, 6 off Betterton near the mouth of the Sassafras River, and 6 on the western shore from Miller Island to North Point. These nets cost from $50 to $150 each. They are usually set in strings containing from 2 to 4 nets each. They are not operated especially for shad, and that species represents only a small proportion of the total catch, the shad yield in 1896 numbering only 9,839, worth $1,099.

The use of pound nets or stake nets is prohibited "in Chesapeake Bay, north of a line 1 mile south of Pool Island, except the bay shore of Kent County up to Howell Point at the mouth of Sassafras River."

POTOMAC RIVER.

This river, the largest and most important tributary of Chesapeake Bay, is formed by the union of the north and south branches on the line between Maryland and West Virginia, whence, forming the boundary line between Maryland and the Virginias, it flows a distance of 290 miles to its entrance into Chesapeake Bay, 75 miles above Cape Henry. Below Washington it is broad and sluggish, forming one of the largest estuaries on the Atlantic coast, covering 370 square miles, not including its tributaries. This estuary is 100 miles in length and varies in width from 2 to 7 miles, with a navigable depth of 16 feet or more at low water, the depth in some places exceeding 100 feet. At Washington, the head of navigation, the fluvial characteristics appear, and from that point to Great Falls, 15 miles above, there are numerous shoals, with several small falls, the most important being Little Falls, at a distance of 5 miles above Georgetown, where the descent is several feet. At Great Falls, where the Potomac crosses the escarpment line, the water passes over a mass of rock, descending 35 or 40 feet, the total fall in a distance of 1½ miles being 88 or 90 feet. Great Falls have always presented a barrier to the upward movement of shad. If they could be passed no serious obstruction would be met with until where the river breaks through the Blue Ridge, just below Harpers Ferry, 60 miles above Georgetown. In 1882 an appropriation of $50,000 was made by Congress for the erection of suitable fishways at Great Falls, and in 1885 the work of construction was begun, the plans providing for a fishway in six sections in the Maryland channel. A high freshet during the night of October 29–30 considerably damaged the partly completed sections, and after examination it was decided that "the fishways were not planned sufficiently strong to withstand the effects of the violent floods of the locality in which they were placed," and the project was abandoned.

That portion of the river below the District of Columbia is entirely within the limits of the State of Maryland, the boundary line between Maryland and Virginia following the extreme low-water mark on the Virginia side of the main body of the river and from headland to headland at the mouths of creeks along the same shore. In 1785, while the boundary line was in dispute and before the adoption of the Constitution of the United States, Maryland and Virginia entered into articles of agreement for the regulation of commerce, navigation, and other industries of mutual interest, and one of the articles provided for a right of fishery in Potomac River in common to the citizens of the two States, and that in the regulation thereof neither State should enforce any law not approved by the other. The effect of this compact has been to prevent any regulation of shad fisheries by either of the two States, and the citizens of both States enjoy equal fishing privileges in the river.

Prior to 1830 shad fishing was prosecuted almost exclusively by means of seines, the fisheries being controlled by the well-to-do riparian proprietors. Nearly every large plantation on the river had its fishing

shore, the returns from which were large, some of them renting for several thousand dollars. Some time during the Thirties drift nets were introduced by fishermen from Delaware River, and by 1835 they had increased to such an extent as to embarrass the seining operations and to materially lessen the profits. A convention of fishermen was held at Alexandria, Va., to protest against the use of drift nets and to take measures to secure legal prohibition of them. This was the beginning of the contest which was waged for years between the riparian owners and the wandering fishermen who have successfully contested the right to equal fishing privileges with the former.

In 1871 it was reported that 24 seines were then used on the Maryland shore of the Potomac, requiring the services of 619 men, 74 boats, and 51 horses, and catching in the spring of that year 110,400 shad, worth $14,353. During the same year 243 drift nets were reported on the same side of the river, with 161,446 square fathoms of twine, requiring 456 fishermen and 213 shoresmen, catching 351,800 shad, valued at $38,698, making a total of 462,200 shad, worth $53,051, taken by residents of Maryland. No reliable estimates or records showing the extent of the fisheries of the Virginia shore during that year are available, but they have generally been more extensive than on the Maryland shore.

A fair idea of the comparative yield of shad in the Potomac during the past quarter of a century may be obtained from an examination of the following table showing the number of shad inspected in the District of Columbia from 1873 to 1896, inclusive, which represents from 50 to 75 per cent of the total yield in the river:

Year.	Jan.	Feb.	March.	April.	May.	June.	Total.
1873							852, 900
1874							628, 637
1875							464, 215
1876							319, 079
1877							131, 199
1878							121, 785
1879			3, 570	116, 938	168, 515	22, 218	311, 241
1880	4	28	10, 110	165, 071	139, 441	6, 145	320, 799
1881			16, 074	233, 716	200, 723	7, 855	458, 368
1882		14	18, 895	226, 164	101, 175	3, 989	350, 237
1883		4	11, 254	171, 641	76, 127	2, 452	261, 478
1884			32, 312	147, 503	50, 802	494	231, 111
1885			6	55, 155	68, 450	1, 847	125, 458
1886			6, 544	133, 733	38, 526	2, 274	181, 077
1887		4	7, 141	151, 694	106, 475	3, 796	269, 110
1888			145	186, 273	117, 316	4, 710	308, 444
1889			6, 902	277, 956	160, 891	2, 828	448, 577
1890	1	38	26, 109	337, 152	54, 509	1, 582	419, 391
1891		14	5, 012	246, 791	63, 653	2, 319	317, 789
1892		4	7, 741	204, 657	44, 298	4, 182	260, 882
1893			16, 809	229, 250	60, 460	1, 459	307, 978
1894	6	25	12, 125	297, 554	74, 301	11, 627	395, 638
1895			27, 256	459, 165	131, 321	5, 568	623, 310
1896		7	10, 254	272, 038	55, 923	4, 938	343, 160

The average annual yield of shad in the Potomac during recent years has been about 750,000. The catch in 1896 was smaller than usual, numbering 684,063, of which 450,825 were obtained by the residents of Virginia and 233,238 by Maryland fishermen. An interdiction exists against shad fishing within the limits of the District of Columbia.

The following summary shows, by States, the number of people employed in each branch of the shad fisheries of the Potomac River in 1896:

Designation.	Virginia shore.	Maryland shore.	Total.
Fishermen:			
Stake-net	21		21
Drift-net	231	241	472
Seine	247	87	334
Pound-net	308	116	424
Bow-net		25	25
Shoresmen	31	39	70
Transporters	17	4	21
Total, exclusive of duplication	855	512	1,367

The following statement shows the boats, apparatus, etc., employed in the shad fisheries of the Potomac River in 1896:

Designation.	Virginia shore.			Maryland shore.			Total.		
	No.	Length (yds.).	Value.	No.	Length (yds.).	Value.	No.	Length (yds.).	Value.
Boats	325		$17,950	195		$6,945	520		$24,895
Stake nets	529	6,133	1,043				529	6,133	1,043
Drift nets	118	67,000	6,155	118	94,500	6,230	236	161,500	12,385
Seines	8	13,600	13,700	5	3,640	4,000	13	17,240	17,700
Pound nets	299		35,175	131		8,175	430		43,350
Bow nets				3		6	3		6
Shore property			16,425			5,100			21,525
Total value			90,448			30,456			120,904

The following statement shows the product of each branch of the shad fisheries of the Potomac River in 1896:

Fishery.	Virginia shore.			Maryland shore.			Total.		
	Roes.	Bucks.	Value.	Roes.	Bucks.	Value.	Roes.	Bucks.	Value.
Stake-net	6,746	4,764	$1,616				6,746	4,764	$1,616
Drift-net	85,440	56,960	11,729	82,128	54,752	$11,459	167,568	111,712	23,188
Seine	47,631	31,754	6,471	25,386	18,674	3,382	73,017	50,428	9,853
Pound-net	114,999	102,531	23,268	31,163	20,535	5,533	146,162	123,066	28,801
Bow-net				360	240	150	360	240	150
Total	254,816	196,009	43,084	139,037	94,201	20,524	393,853	290,210	63,608

The drift-net grounds extend from Mathias Point to Alexandria, a distance of 60 miles, but those nets are operated most extensively from Indian Head to River View. Below Mathias Point the water is salty and too clear and sluggish to permit the successful use of this form of apparatus, except when heavy rains have swollen the river. The nets range in length from 300 to 1,000 yards, averaging above 700 yards, and in depth from 30 to 90 meshes, depending respectively on the width and depth of the reach in which they are operated. They are usually so rigged as to float several feet below the surface of the water, being suspended by buoy lines at intervals of 15 or 18 feet. Those nets 60 to 90 meshes deep, when operated in the main channel, are buoyed with the upper line from 8 to 10 feet below the surface, permitting all boats, except the largest steamers, to pass over them without injury.

There are two general methods of hanging the drift nets, viz, the "single line" and the "double line." In the former the lower portion of the net is permitted to swing freely, having no bottom line and not being weighted. The mesh in these is generally $5\frac{1}{8}$ or $5\frac{1}{4}$ inch. The second form of nets, known as "double line," is operated mostly on the shoals, and consequently is usually longer and shallower. In these nets a line extends the entire length of the bottom, to which leaden weights are attached, serving to hold the net in a somewhat rigid position, and the mesh is usually 5-inch. The reason for the difference in the size of the mesh in the "single-line" and "double-line" nets is that the bottom of the former, swinging clear and free, readily yields to every motion of the fish enmeshed therein and the fish soon becomes wound up and entangled in the meshes, being unable to either withdraw or force its way through the net; while the latter, being in a somewhat unyielding position in the water, due to the weighted bottom line, is not easily entangled, and the mesh must be sufficiently small to hold the fish firmly. The "single-line" nets are usually from 50 to 90 meshes deep and the "double-line" nets from 30 to 60 meshes in depth. The former are drifted mostly during slack water, and consequently remain in the water usually only two or three hours at a time. The latter are operated on both tides, and may remain in the water a half day or longer. An ordinary gill net, full-rigged, costs \$100 to \$125; after being used one season its value is reduced one-half, and three seasons' work usually renders it unfit for further use. The season begins about the last week in March and ends about the middle of June. The yield in 1896 was unusually small, only 50 or 60 per cent of that obtained in 1895. The yield by the 118 boats from the Virginia shore numbered 85,440 roes and 56,960 bucks, a total of 142,400, while the Maryland fishermen obtained 136,880, of which 82,128 were roes and 54,752 buck shad. The price received by the fishermen was also low, averaging between \$8 and \$8.50 per hundred.

The stake-net fishery of Potomac River is of little importance, consisting of a few strings of nets operated in the lower half of the river by residents of Virginia. The total number used in 1896 was 529, set in 9 strings, requiring the services of 21 men who employed 12 boats, worth \$935. The catch was quite small, numbering only 6,746 roe shad and 4,764 bucks, worth \$1,616.

The pound-net fishery is confined almost entirely to the lower half of the river, the nets set for shad above Maryland Point being few in number and cheaply constructed. Pound nets were introduced about 1875, and since then they have constantly increased in favor. In 1889 there were 330 pound nets; in 1890, 376; in 1891, 411, and in 1896, 430. Of those used in 1896, 299 were operated by Virginians and 131 by residents of Maryland. The former, however, are much larger and catch many more shad than those on the Maryland side of the river, the Virginia nets being most numerous near the mouth, while most of the Maryland nets are between Nanjemoy Point and Blakistone Island.

The mesh in most of the shad pound nets has the following dimensions: Leader, 7 inches; first "pound," 6; second "pound," 4 or 5, and main "pound," 4 or 4¼ inches. Some of the nets have 2½-inch mesh, in order to retain the alewives; while a few of the regular shad nets have a backing of 2½-inch mesh, against which the fish are bunted when the net is lifted, the alewives not escaping readily through the large mesh except when the net is being lifted. There is a tendency to increase the size of the mesh, and during the last year it was 12 inches in some of the leaders, and this will probably be exceeded, as the tide runs strong and a small mesh trap is more likely to be swept away than one of larger mesh, and it also accumulates more seaweed and other floatage. The "pounds" are usually from 40 to 60 feet square and the leaders from 200 to 250 yards in length, the average cost of the nets approximating $100. The total catch of shad by the pound nets in 1896 numbered 269,228, of which 114,999 roes and 102,531 bucks were obtained by Virginia fishermen, and 31,163 roes and 20,535 bucks by residents of Maryland. This yield was not so large as usual, nor were the prices so high as in former years. Unusually warm weather in April resulted in glutting the market, and prices did not recover during the season. The lowest prices received were 6 cents for roes and 3 cents for bucks, but from two to three times that amount represented the average prices. The total value of the above yield was $28,801, of which $23,268 represented the Virginia and $5,533 the Maryland catch.

Seining was formerly the most extensive branch of the Potomac River shad fisheries, but its importance as compared with the drift-net and pound-net fisheries is becoming less each year.

The following shows the location and extent of this fishery in 1896:

Localities.	Distance above Smith Point.	Number of seines.	Length.	Number of men, including shoresmen.	Number of shad caught.		Value.
					Roes.	Bucks.	
Virginia:	*Miles.*		*Yards.*				
Stiff's Wharf	70	1	800	17	1,200	800	$172
Marlboro Point	74	1	1,800	37	4,200	2,800	560
Gumms Point	77	1	1,200	20	450	300	120
Wide Water	82	1	2,200	50	4,800	3,200	688
Freestone Point	91	1	2,400	47	14,181	9,454	1,891
Occoquan Creek	93	2	2,000	32	4,800	3,200	640
Stony Point	96	1	3,200	75	18,000	12,000	2,400
Maryland:							
Chapman Point	99	2	1,200	80	11,250	9,250	1,550
Bar Landing	102	1	1,600	18	4,536	3,024	552
Moxley Point	107	1	440	16	2,400	1,600	320
Tulip Hill	109	1	400	12	7,200	4,800	960
Total	....	13	17,240	404	73,017	50,428	9,853

At Great Falls, 14 miles above Georgetown, there are a few bow nets used each spring from the last week in April to the first or second week of June. These nets are operated from a point known as "Shad Rock," which projects into the water on the Virginia shore just below the principal falls. Three bow nets were reported from that locality in 1896, the yield numbering 360 roe shad and 240 bucks.

PATUXENT RIVER.

The Patuxent, the most important shad stream between the Potomac and the Susquehanna, is situated wholly in Maryland, rising in Howard and Montgomery counties, and flows a distance of 110 miles to its entrance into the Chesapeake, 20 miles above the mouth of the Potomac. It is navigable for steamers of 7 or 8 feet draft to Bristol, 46 miles from the mouth. Aside from the numerous apparatus of capture, fish meet with no serious obstruction to their ascent of the river until near Laurel, 95 miles from the mouth, where the river is crossed by two dams for developing water-power. Because of the numerous fisheries in the lower half of the river and the narrowness of the stream very few shad ever reach Laurel and none ever pass above the dams at that town. Of the 52,354 shad taken in 1896, 24,375 were obtained by means of seines, 19,700 by drift nets, and 8,279 by pound nets. As the fish enter the river they encounter first the pound nets near the mouth; after proceeding about 35 miles they reach the lowest seine beach, and a short distance farther up, between Dunkirk and Leon, they reach the drift-net grounds.

The pound nets operated in the lower end of the river are mostly between Point Patience and Drum Point. They are small, averaging in value only $125 each, and have small mesh, depending more on taking alewives than shad. The catch of shad by the 33 nets in 1896 numbered 3,305 roes and 4,974 bucks, worth $910 at local values. The yield of alewives in the same nets numbered 795,830, valued locally at $2,152.

The seine beaches are located entirely in the upper reaches in Prince George and Anne Arundel counties, from Hill's Landing to Leon where the river is 500 or 600 feet wide. The seines range from 100 to 200 yards in length, with 2½ or 2¾ inch mesh, and are worth from $80 to $300 each. Ten shad seines were used in 1896, aggregating 1,700 yards in length and $1,815 in value. The catch numbered only 9,244 roe shad and 15,131 bucks, valued locally at $2,680.

Drift nets are operated only in a reach 5 or 6 miles in length, in the vicinity of Dunkirk and Leon. The nets are each about 200 feet in length, with from 5 to 5⅜ inch mesh, and cost $10 or $12. Of the 18 drift nets used in 1896, aggregating 1,205 yards in length, 10 hailed from Leon, Anne Arundel County; 7 from Dunkirk, Calvert County, and 1 from Nottingham, Prince George County. The catch numbered 19,700 shad, of which 8,520 were roes and 11,180 bucks, the aggregate value being $2,277.

SUSQUEHANNA RIVER.

While the Susquehanna is one of the longest rivers of the Atlantic coast, only 12 miles of its length is within the limits of Maryland. Since most of this river is situated in Pennsylvania, its general physical characteristics will be noted in the description of the shad fisheries of that State. The Maryland section ranges from a half to nearly 1 mile in width, but as the water is very shoal it is navigable only a few miles above the mouth. The fall in the 12 miles from the Pennsylvania

line to the entrance of the river into Chesapeake Bay is 69 feet, an average of 5.75 feet per mile, the greatest within a short distance of the mouth that exists on any large river of the Atlantic coast. The importance of the Susquehanna River shad fisheries suffers somewhat in comparison with those of the Susquehanna Flats. The latter fishing-grounds are usually more profitable, but as a rule, they also require larger and more costly apparatus of capture than the river fisheries. The apparatus used in the river consists of drift nets and seines near the mouth, and fall traps and bow nets in the rapids above Port Deposit.

The gill nets are drifted between the Baltimore and Ohio Railroad bridge and Port Deposit. They are similar to the nets used at the head of Chesapeake Bay, differing only in length, as the reach is not very wide. Of the 49 boats engaged in this fishery in 1896, 33 hailed from Port Deposit, 9 from Frenchtown, 5 from Perryville in Cecil County, and 2 from Lapidum in Harford County. They carried 28,672 yards of twine in lengths averaging from 125 to 130 yards each, the size of the mesh being mostly 5½ inches. The yield was much smaller than usual, the catch numbering only 14,060 roe shad and 21,480 bucks, the total local value being $3,949.

The seines are of two general sizes, the larger being from 600 to 800 yards in length, while the smaller ones are from 100 to 150 yards long. Of the former size there were 7 used in 1896, with an aggregate length of 5,200 yards and valuation of $4,700, requiring the services of 265 fishermen and 71 shoresmen. The catch was scarcely up to that of an average season, numbering 16,831 roe shad and 9,171 bucks, valued locally at $3,222. One of the seines caught 24,000 shad during the season of 1883. The small seines numbered 5, with 2¼-inch to 4½-inch mesh. Thirty men were required, and the catch numbered 1,759 roe shad and 2,584 bucks, worth $507, making a total of 30,345 shad, worth $3,729, taken in seines.

At various points in the rapids of the river below the Pennsylvania line there are several "fish pots" or fall traps, consisting of a small breakwater of rocks forming a triangle with the apex pointing downstream. At the apex is placed a slat-work wooden frame with the rear end raised a foot or two above the surface of the water and the front or up-river end resting on the bottom. In passing along the stream the fish meet these stone breakwaters, and following them reach the traps, upon and over which they are washed by the current, falling into a box placed under the raised or downstream end of the trap. These traps have engendered considerable bad feeling among the fishermen on the river. An interdiction exists against their use in Pennsylvania, but they are unrestricted in the Maryland section of Susquehanna River. The number reported in 1896 was 15, and the catch of mature shad numbered 778 roes and 1,225 bucks, worth $259.

On account of the increasing scarcity of fish, bow nets are not used so extensively as was formerly the case. They are operated from boats and also from rocks situated in favorable places in the channel, one

man being required for each net. The number of nets reported in 1896 was 8, with a yield of 1,600 shad, worth $220, making a total of 69,488 shad, worth $8,157, taken in the Maryland section of the Susquehanna.

Considerable complaint is made in this portion of the river regarding the refuse from a sulphide paper mill established in 1891 at Conowingo, about 10 miles from the mouth of the river. When the water is low this refuse moves back and forth with the tide, doing considerable injury to the fisheries, but during high water the refuse is carried out into the bay, where it does little damage.

The rivers entering Chesapeake Bay from the east are quite different from those on the western side of the bay. The eastern tributaries are more numerous, and, draining a low, flat region, their declivity is nearly uniform and without falls. Excepting two or three of the smaller ones, they rise in the somewhat elevated area forming the western portion of Delaware and flow in a general southwesterly direction, expanding at their mouths into broad estuaries. They are tidal nearly to the upper limits, and are navigable for vessels of 5 or 6 feet draft for three-fourths or more of their length. Beginning at the southern boundary, the most important are the Pocomoke, Wicomico, Nanticoke, Choptank, and Chester rivers, yet the tributaries of these and the smaller streams are so numerous that there is probably no point on the Eastern Shore of Maryland over 8 miles distant from tide water. The shad fisheries of each of these estuaries and their tributaries will be described in succession.

POCOMOKE RIVER.

Pocomoke River rises in Great Cypress Swamp, on the line of Maryland and Delaware, whence it flows between narrow banks a distance of 115 miles to its entrance in Pocomoke Sound. It is navigable for vessels of 9 feet draft to Snow Hill, about 50 miles from the mouth. The water is quite muddy, due to the suspension of the black alluvial soil from its source. Much of this earthy matter is deposited at the mouth of the river, where the accumulations of years extend for an average depth of 20 feet over 16 square miles, forming the "muds," over which at low tide there is a depth of 4 or 5 feet of water. The shad fisheries of the Pocomoke are of considerable local importance, and extend from the mouth of the river to several miles above Snow Hill, the principal fisheries existing at Pocomoke, Mattaponi Ferry, and Snow Hill. The yield in 1896 was less than usual, numbering 29,752, of which 23,713 were taken by men living in Worcester County and 6,039 by Somerset County fishermen. Of the total yield, 17,692 or 60 per cent were buck shad. The forms of apparatus are bow nets, drift nets, seines, and fyke nets.

The bow-net or dip-net fishery yields 80 per cent of the total number of shad taken on the Pocomoke. The bow nets are similar to those used in the Carolinas, except that they are of more costly material. The frame is of tough but light wood, bent in a long, oval shape, with the longest diameter from 14 to 16 feet. Within this frame is a loose net

of the best hemp twine, No. 35 or 40, with a "hang" of 5 or 6 feet, the twine measuring 200 meshes around the frame, the mesh being 4¼ inches. Usually two men are required for each net, one of whom operates the net while the other propels the boat; but in some instances the net is operated from a stationary point or the boat is permitted to drift with the current, requiring the services of only one man. The catch by the 97 bow nets used on this river in 1896 numbered 23,812, of which 14,052, or 60 per cent, were bucks. The season begins during the third week of March and lasts about two months, the fish being most numerous the second or third week of April. The season in 1896 was unusually short, and consequently the catch was small, averaging only 235 shad per net. Yet this average was far in excess of that for any other river in the United States, the nearest approach being an average of 95 shad per net on Santee River, in South Carolina. During certain years as many as 1,000 shad have been taken in a single bow net on the Pocomoke. The catch is practically all marketed in the towns and settlements adjacent to the river, the price received ranging from 10 to 30 cents each.

Drift nets are used in the lower end of the Pocomoke, from Shelltown to Rehobeth, and near Snow Hill, the head of navigation. They are from 40 to 60 yards long "in gear," and from 44 to 52 meshes deep, with 4¾ to 5¼ inch mesh, the cost ranging from $6 to $9 each. Two nets are usually carried by each boat, and generally two men are required, but in the headwaters one fisherman operates each boat. The boats in 1896 numbered 21, using 2,180 yards of twine and catching 1,293 roe shad and 1,905 bucks, valued locally at $491. The catch was the smallest for several years, the average being only 152 shad per boat.

There were 6 seines used on the Pocomoke River in 1896, 1 at Cedar Hall, 4 near the mouth of Nassawango Creek, and 1 at McKee Island, above Snow Hill. They were from 70 to 100 yards in length, 8 to 12 feet deep, with 2¼ to 2½ inch mesh. The shad season extended from the last week in March to the first week in June, and the catch numbered 2,537, of which 63 per cent were bucks. In addition to this species, quantities of alewives, perch, catfish, etc., were secured in the seines.

Fyke nets complete the enumeration of the apparatus in which shad are taken in the Pocomoke River, these nets being used by residents of Rehobeth and Shelltown, near the mouth of the river. They are not operated especially for shad, and secure also many eels, perch, alewives, catfish, pike, etc. They are set from the middle of September to near the last of April, and the catch of shad in the 16 nets in 1896 numbered 115 bucks and 90 roes, making a total of 29,752 shad secured in Pocomoke River.

Between Pocomoke and Wicomico rivers there are three small streams entering Tangier Sound, viz: Annemessex, Big Annemessex, and Manokin, in which a very few shad are to be found each year, especially in the last named; but there are no established fisheries, and the shad taken incidentally are used in the homes of the fishermen.

WICOMICO RIVER.

Wicomico River rises near the elevated rim which encircles Great Cypress Swamp, in which Pocomoke River has its origin, and after flowing a distance of 35 miles enters the head of Tangier Sound. Near its mouth it expands into a broad, shallow sheet of water, called Monie Bay, characteristic of nearly all tributaries of Chesapeake Bay. It is navigable for vessels of 7 feet draft from the bay to Salisbury, 23 miles above the mouth, where the lowest milldam crosses the stream. For many years the river was made a receptacle for refuse matter from the numerous sawmills on its banks, to the great injury of the spawning-grounds; but during recent years this refuse has been burned in the mill yards. Considering its small size, the yield of shad on the Wicomico is remarkable, with a navigable length of only 23 miles the product averaging about 75,000 shad annually. In actual yield it ranks third among Eastern Shore rivers, being surpassed by the Choptank and the Nanticoke. The apparatus employed consists of drift nets, stake nets, seines, pound nets, and fyke nets, the catch by the first named in 1896 being 67 per cent of the total yield on the river.

Drift nets are operated from White Haven to Williams Point, 1 mile below Salisbury, a distance of 12 miles. The length of the nets varies from 100 yards at White Haven to 40 yards at Williams Point, and the depth from 53 to 31 meshes, with from $4\frac{7}{8}$ to $5\frac{1}{8}$ inch mesh. The season begins about the middle of March and lasts six weeks, the catch ranging from 100 to 900 shad to each boat. The yield in 1896 was unusually small, averaging only 274 shad per boat, the catch by the 166 boats, using 307 nets, numbering 21,275 roes and 24,123 bucks, valued locally at $5,442.

There are usually several rows of stake nets operated each year near the mouth of the Wicomico River by men living at Victor and Mount Vernon, in Somerset County. The nets are 20 yards long, 40 meshes deep, with 5 to $5\frac{1}{2}$ inch mesh, and are worth about $4 each. The season begins about the third week of March and lasts four or five weeks, the yield averaging about 250 shad per boat. In 1896 there were 19 boats, using 70 stake nets, taking 2,320 roe shad and 2,405 bucks. The number of stake nets in this portion of the river is increasing and the yield during recent years has been good, although somewhat less than usual last year.

During the season covered by this report there were 5 "double-heart" pound nets located on the north side of Wicomico River 4 miles below White Haven, being set across the current on the side of the channel, with one net on each string. They cost about $100 each, and the 5 nets required the services of 6 men and 3 skiffs. The season began March 14 and ended the first week in May, the catch numbering 7,064 roe and 5,472 buck shad, worth $1,667 at local valuation, and in addition thereto 57,860 alewives and also numerous striped bass, perch, catfish, spots, suckers, squeteague, etc., were taken.

Three small seines were operated in 1896 near the headwaters of the river within 4 miles of Salisbury, the length ranging from 145 to 340 yards each, with 2¼-inch mesh in the bunt. The season for shad began the second week in March and ended the latter part of May, the catch numbering 1,544 roes and 2,510 bucks, worth $452, the seines also taking alewives, striped bass, perch, catfish, etc.

The fyke nets are not set especially for shad. They are located in the lower portion of the river, 18 sets, or 36 nets, being used in the spring of 1896, requiring 9 men and 5 boats to fish them. The season for shad extended from the middle of March to the middle of May. The yield numbered 635 roes and 667 bucks, making a total catch in the Wicomico of 32,838 roe shad and 35,177 bucks, valued locally at $8,480. Except such as are sold in the immediate locality, most of the shad from this river are sent to Baltimore.

For several years the State of Maryland has maintained a small shad hatchery at Salisbury, on the Wicomico River, from which several million fry are annually distributed, not only in the Wicomico but in other streams of the peninsula.

NANTICOKE RIVER.

The headwaters of Nanticoke River are in Kent and Sussex counties, Del., uniting in a navigable stream at Seaford and 11 miles lower down crossing into Maryland. About 5 miles from the Delaware line it receives the waters of Marshyhope Creek, and from this junction flows 30 miles to its entrance into the head of Tangier Sound. In the lower 10 miles the river is a mile or more in width and the channel 12 to 30 feet deep; thence to Vienna, 25 miles from the mouth, the width is from 500 to 150 yards and the depth about the same as in the lower portion. From Vienna to the entrance of Marshyhope Creek the width is from 200 to 250 yards and the depth generally more than 20 feet. Above that creek the width and depth gradually diminish to 100 yards and 8 feet, respectively, at Seaford, where navigation ceases. Nanticoke River ranks third in the extent of its shad fisheries among the Maryland rivers, being surpassed only by the Choptank and Potomac. The fisheries extend from the mouth to several miles above Seaford, the total yield in 1896 being 216,308 shad, of which 52,467 were obtained in Delaware and 38,660 in Marshyhope Creek, leaving 125,181 as the number taken in the Maryland portion of the main river. The present chapter deals only with the latter section, notes on the portion located in Delaware being reserved for the description of the fisheries of that State. Drift nets, stake nets, pound nets, and fykes are the only forms of apparatus used in the shad fisheries of the Maryland section of the Nanticoke, and over 50 per cent of the yield is obtained by means of the first named.

Drift nets are operated from Quantico Creek to the Delaware line, and are most numerous from Vienna to Sharptown. They measure from 175 yards in length below Vienna to 115 yards at Galestown, and

from 65 to 51 meshes deep, with $4\frac{5}{8}$ to $5\frac{1}{4}$ inch mesh. Each boat usually carries two nets and requires the services of two men. The season begins about the middle of March and lasts seven or eight weeks. The drifting begins usually at 1 o'clock on Monday morning of each week and on other secular days at 3 o'clock a. m., continuing until daylight. The largest catch in one day by any one boat in 1896 was 316 shad, taken on Monday, March 23, near Vienna. In one drift of a mile in length, with a net 165 yards long, 115 shad were taken. The total catch by the 73 drift-net boats numbered 62,876 shad, of which 36,566, or 58 per cent, were bucks. This catch was smaller than usual, the prices being so low that many of the men ceased fishing by the middle of April.

Stake nets are used in the extreme lower end of the Nanticoke from Roaring Point to Sandy Hill. The total catch in the 282 nets numbered 11,930 roes and 5,735 bucks, valued at $2,015. A very noticeable difference is observed in the proportion of roe and buck shad reported from Sandy Hill and those reported from fishing stations farther down the river. Of the total catch at Roaring Point, Jesterville, and Walterville over 80 per cent were roe shad, whereas at Sandy Hill the proportion that the roe bore to the total yield was less than 60 per cent. This is due to the fact that the mesh of most of the nets at Sandy Hill was 5 inches, whereas at the former places it was mostly $5\frac{3}{8}$ inches. One boat at Jesterville using 25 nets, with $5\frac{3}{8}$-inch mesh, caught 1,083 roes and 165 bucks in 1896.

While the pound nets in Nanticoke River are not set especially for shad, yet numbers of this species are taken therein. Of the 26 pound nets in 1896, 4 were set between Nanticoke Point and Roaring Point and the remaining 22 above Quantico Creek. The 4 at the mouth of the river were large nets, worth over $300 each, while the others cost from $50 to $80 each. The mesh in the bowl of the nets was from $2\frac{1}{2}$ inches to 3 inches, small enough to retain alewives, of which large quantities were obtained.

The yield of shad was somewhat larger than usual, the 4 nets at the mouth of the river taking 8,596 bucks and 6,827 roes, the proportion of the roe shad being greater than for several years preceding. The remaining 22 nets took 8,680 roe shad and 11,200 buck shad, making a total of 35,303 shad taken in the pound nets, worth $3,022 at local values.

The fyke nets set in the lower part of the river, below Quantico Creek, catch a few shad with other fish. They are operated generally in sets of 2 nets each, in from 4 to 8 feet of water. In 1896, 143 fyke nets were used in the Nanticoke, of which 82 were owned at Wetipquin and 56 at Sandy Hill. The yield of shad was 5,897 bucks and 3,440 roes, with a valuation of $795, the price being unusually low. The Nanticoke River fyke nets produce over 50 per cent of the entire yield of shad in all the fyke nets operated in the Chesapeake Bay and tributaries, including both Maryland and Virginia.

Marshyhope Creek.—The northwest branch of Nanticoke River diverges from the main stream at Riverton, a small village in Wicomico County, and extends about 34 miles to the swamps of Kent County, Del. It has an average depth of 5 or 6 feet up to Federalsburg, 20 miles from the mouth, where it is crossed by a milldam. Considering its size, the shad fisheries of Marshyhope Creek are quite extensive. They are prosecuted from the mouth to Federalsburg, but are most extensive about Brookview, known until recently as Crotcher Ferry. The catch in 1896 numbered 38,660 shad, of which 24,920 were taken in drift nets, 7,180 in seines, and 6,560 in small pound nets.

The drift nets average nearly 100 yards in length, from 49 to 53 meshes deep, with 5 to 5¼ inch mesh. The season begins usually the last week in March and extends to about May 20. The total catch by the 38 drift-net boats in 1896 was 14,140 roes and 10,780 bucks, valued locally at $2,366. Between Brookview and Federalsburg, on the Marshyhope Creek, there were 8 seines operated. These ranged in length from 40 to 150 yards, aggregating 545 yards, with 2½-inch mesh. Forty men were employed in hauling them, the catch being 3,400 roes and 3,780 bucks, worth $823. The popular local opinion is adverse to the use of pound nets, yet 12 small nets were used above Brookview in 1896, with a total shad yield of 6,560, almost equally divided between roes and bucks. Several of the pound nets in Marshyhope Creek and a number in the Nanticoke are of an improved pattern, invented and patented by Capt. M. B. Marshall, of Vienna, Md.

FISHING BAY.

This bay is a broad estuary, 11 miles in length and 2 or 3 in width, connecting Transquaking and Blackwater rivers with the head of Tangier Sound. The depth of water in the channel approximates 20 feet, but in the extreme upper end and on the sides of the channel the depth of water averages about 5 feet. During some seasons the shad yield of Fishing Bay is of much local value, but in 1896 it was extremely small, the total catch in that year being about 9,790, whereas the average catch is three or four times that amount, stake nets and pound nets being the apparatus used.

The stake nets measure 16 or 18 yards in length, with from 5 to 5½ inch mesh. Being set on the flats at the sides of the channel, they are very shoal, averaging 16 meshes in depth. The last season was short, extending from March 16 to the middle of April, when crabs and eels became so numerous that fishing was abandoned. The catch in the 388 stake nets amounted to 4,300 roe shad and 3,865 bucks, valued locally at $991. Of the four small pound nets used, two were located near the entrance of Blackwater River at the head of the bay, and two off Fishing Point, about 6 miles above the mouth of the bay, the yield of shad numbering 660 roes and 965 bucks. The value of these nets and the men, boats, etc., employed are set forth in the tables showing the extent of the Maryland shad fisheries.

Transquaking River.—This is a small stream situated wholly in Dorchester County and entering Fishing Bay at the extreme northern part. Shad are taken by near-by residents, principally for local use. There are three forms of apparatus used, viz, pound nets, "stick weirs," and bow nets, the catch by the first named being over twice as great as by the other two combined. The pound nets are small, costing probably $70 each, and are operated from the 1st of March to the end of April, and also in the fall. The number used in 1896 was 17, catching 3,846 roe and 6,378 buck shad, valued locally at $920. The "stick weirs" are constructed by fixing sticks and brush in the bed of the river so as to form a weir. They are rude contrivances, costing possibly $15 each, and the catch is entirely for local use, the yield in the 12 weirs last season approximating 850 roe shad and 1,020 bucks. In addition to shad, many alewives and other species are taken in both pound nets and weirs.

A few bow nets are used on the Transquaking and its principal tributary, the number in 1896 being 20, yielding 1,600 shad, about equally divided between roes and bucks.

Blackwater River.—This stream is situated wholly in Dorchester County and empties into Fishing Bay, not far from the Transquaking. About 8 miles above its mouth it separates into two branches, known, respectively, as Little Blackwater and Big Blackwater. Shad ascend this river and its branches to the uppermost limits, and are taken at numerous points in drift nets and pound nets. The drift nets average 40 yards in length, 7 feet in depth, with 5-inch mesh. The 34 drift-net boats in 1896 required 36 men and used 46 nets, 1,840 yards in length, worth $184. The season began about the third week of March and lasted four or five weeks. The catch approximated 3,700, about evenly divided between roes and bucks. The pound nets and "stick weirs" used in the Blackwater and tributaries are similar to those in the Transquaking, except that they are somewhat smaller. Of the 39 used in these waters, 24 were in the main river, 9 in Little Blackwater, and 6 in Big Blackwater. The catch was 5,645 roe shad and 3,815 bucks, valued at $1,051, making the total yield of shad on the Blackwater River and tributaries 13,160, worth $1,480. Very few of these shad are shipped to distant markets.

CHOPTANK RIVER.

The Choptank is the largest and most important of the Eastern Shore rivers. From the Chesapeake to Hunting Creek, a distance of 30 miles, it is a tidal estuary, the width ranging from 5 miles to 500 yards and the depth in the channel from 70 to 20 feet, the water being nearly as salty as in Chesapeake Bay. About 18 miles above Hunting Creek it receives the waters of Tuckahoe Creek, a tributary nearly as long as the main stream above this point. The river is navigable for vessels of 9 feet draft to Denton, 7 miles above Tuckahoe Creek, and small-boat navigation extends to Greensboro, 8 miles further. The yield

of shad in 1896 was nearly one-half of the total product on all the Eastern Shore streams and nearly five times as many as were taken on Susquehanna River, numbering 276,076 on the main stream and 62,344 on Tuckahoe Creek, a total of 338,420, valued locally at $35,810. Of the total yield 183,730, or 54 per cent, were bucks. The forms of apparatus used are pound nets, drift nets, seines, and stake nets, with a few shad taken in fyke nets.

The location of pound nets extends from Nelson Point, near the mouth of the river, to 2 or 3 miles above the entrance of Tuckahoe Creek, but the nets are most numerous between Oxford and Windy Hill, a distance of 25 miles. In 1896 there were 24 strings with 2 pound nets each, 2 with 3 nets in a row, one string of 4 nets in a row, and 127 nets set individually, making a total of 185. Those near the mouth of the river average in value about $120, while the nets in the upper portion cost less than $40 each. The former are set more particularly for striped bass, bluefish, squeteague, perch, catfish, etc., and take comparatively few shad, while the catch by the latter consists largely of shad and alewives. The season begins in the lower part of the river during the second week of March, in the upper portion about ten days later, and lasts about two months, the bulk of the shad being taken from April 10 to May 10. Shad were somewhat scarce last year, and about the middle of April the weather became warm and prices fell so low that they did not even cover the expense of shipment, resulting in many of the nets being taken up. One net set near Oxford yielded 2,260 in one lift in 1895, whereas the yield during the entire season of 1896 did not equal that amount. The catch in the 185 nets numbered 52,226 roe and 62,532 buck shad, valued locally at $11,811.

The drift-net fishery is most extensive from the mouth of Tuckahoe Creek to Denton, but this branch of the shad fisheries is prosecuted from Windy Hill to the head of the river. The length of the nets ranges from 60 to 200 yards each and the depth from 40 to 60 meshes, according to the width and depth of the reach in which operated. From 2 to 5 nets are carried by each boat, the latter worth from $6 to $20 and having almost invariably a crew of two men. The season begins about the end of March and continues until nearly the middle of May. In 1896, on account of the low prices of shad, many fishermen ceased fishing earlier than usual, and the total catch by the 118 drift-net boats numbered only 33,281 roe and 47,310 buck shad, valued locally at $8,541.

The upper limit of the stake-net fishery on the Choptank is in the vicinity of Hunting Creek, near the lower limit of the drift-net fishery, and from this point to Castle Haven, a distance of 18 miles, these nets are quite numerous. They are set on the sides of the channel where the water is from 10 to 16 feet deep. The length of nets ranges from 12 to 25 yards each and the depth from 25 to 45 meshes, dependent respectively on the strength of current and the depth of water where they are located. The size of mesh is mostly 5 inches, a few nets of $5\frac{1}{8}$-inch mesh being employed also. From 10 to 100 nets are used by

each boat, the average number being about 40 or 45. The last season began about March 20 and lasted six or seven weeks, the yield by the 34 boats numbering 18,925 roe shad and 16,350 bucks, worth $3,813.

All the shad seines on Choptank River are operated within 8 miles of Denton, from Williston to Greensboro, in Caroline County. The length ranges from 120 to 325 yards each, and the depth from 10 to 30 feet. The seine shores are not so valuable as twenty or more years ago, but at present are worth from $50 to $500 each. In 1896 there were 14 seines operated on this river, with an aggregate length of 3,293 yards, and valuation of $1,460, requiring the services of 71 men, 14 boats worth $189, and $4,200 of shore property. The season began the third week of March and ended on May 15, as required by a State law. The large seines make about 12 hauls each day during the run of fish, the smaller ones being hauled somewhat more frequently. The most important of the seine fisheries is the Cedar Island fishery, owned by Mr. B. G. Stevens, which in some seasons takes 10,000 or 12,000 shad. The total shad yield in the 14 seines was 45,050, of which 24,110 were bucks, the local value being $5,183.

Between Dover Bridge and the entrance of Tuckahoe Creek there are usually a score or more fyke nets, in which a few shad are taken, the yield in 1896 numbering 402, of which over 70 per cent were bucks. Until recently there were several "pound weirs," or "stick weirs," in the headwaters of the Choptank, but legislation adverse to their use resulted in this branch of shad fishery being abandoned in 1895. Nearly all the shad taken in the Choptank River are shipped by steamer to Baltimore, and as most of them reach market after April 10, when large supplies are being received from Virginia waters and Delaware Bay, the price at which they are sold is necessarily quite low. This was especially true during the season herein reported, when the market was so glutted about the middle of April that many Choptank River shad were thrown away, and other shipments did not bring enough to pay expenses of marketing them.

Tuckahoe Creek.—This is the only tributary of Choptank River that has shad fisheries of any importance. Branching off about 8 miles below Denton, it is navigable for vessels of 8 feet draft for a distance of 10 miles. A small shad hatchery has been maintained for many years by the State of Maryland at Cowarts Point, a few miles above the mouth, from which five or ten million young shad are annually distributed. The shad fisheries of Tuckahoe Creek extend from the Choptank to Hillsboro, the yield in 1896 being 62,344, rendering it one of the most important shad streams on the Atlantic coast for its size. The forms of apparatus used are drift nets and seines, with a few pound nets and weirs.

The drift-net stations on Tuckahoe Creek are Cowarts Point (14 boats) and New Bridge (2 boats) in Caroline County, and Rees Landing and New Bridge (13 boats), Covey Landing (5 boats), Frank Landing (2 boats) and Todd Landing (2 boats) in Talbot County.

The nets are from 60 to 90 yards in length and are about 55 meshes deep, with 5 to 5¼ inch mesh. The 38 boats in 1896 used 117 drift nets, with an aggregate length of 8,802 yards and valuation of $1,140. The season began about the 1st of April and closed, according to law, on May 15. The catch per boat ranged from 200 to 2,000 shad, and averaged something over 1,000, the total catch of the 38 boats being 39,670, almost equally divided between roes and bucks, the number of the former being 20,040 and the latter 19,630.

The seine beaches on Tuckahoe Creek extend from Hillsboro to within 8 miles of the mouth of the river. Eight beaches were occupied last year, of which 2 were new ones. The seines range in length from 110 to 300 yards and from 9 to 37 feet in depth, with 2½-inch mesh generally. The catch of shad numbered 9,001 roes and 13,194 bucks, the proportion of the roes being smaller than usual.

Several pound nets and fyke nets are operated from the Talbot side of Tuckahoe Creek, taking a few shad, as well as alewives, perch, catfish, etc. Nine pound nets and 34 fykes were used in 1896, the former taking 283 and the latter 196 shad, as appears from the table showing the extent of the Maryland shad fisheries. Except sufficient for local consumption and for sale in the neighboring settlements and towns, all the shad taken on Tuckahoe Creek, as well as on Choptank River, are shipped to Baltimore by the daily steamers connecting that port with the river.

The local effect of close seasons is well illustrated by the condition on Choptank River and Tuckahoe Creek. In the lower half of the Choptank the shad season begins about the middle of March and ends about the 10th of May, whereas in Tuckahoe Creek and the upper portion of the Choptank the season begins about the 1st of April and closes by law on May 15, giving those sections nearly two weeks less of fishing than is enjoyed in the Lower Choptank. As a matter of fact, taking 1,000 shad after May 15 is generally less injurious to the future prosperity of the fishery than taking an equal number before that date, since the percentage of spawned shad in the former lot is greater than in the latter, thus yielding many more young shad when the fish are caught after May 15 than when taken before that date. Catching a shad immediately before it has spawned certainly prevents it from adding its quota to the supply of young fish; but this is also prevented if the shad be caught near the mouth of the river a month or more before its spawning period. It can not be denied, however, that many eggs are destroyed when seines are dragged over the spawning-beds.

ST. MICHAEL RIVER.

Eastern Bay is a side elongation of Chesapeake Bay, covering about 100 square miles and receiving the waters of the St. Michael, Wye, and smaller rivers. There are few fish in this bay, and the only one of its tributaries in which the shad fishery is of any consequence is St. Michael River. This small estuary, lying wholly in Talbot County,

is 16 miles long and varies in depth from 12 fathoms to 8 feet or less. Shad fishing is confined to the operation of several strings of stake nets, the yield finding a market in the near-by settlements. Sixty men engaged at intervals in this fishery in 1896, using 31 boats and 92 nets, 3,690 yards in length. The season began March 25 and closed the beginning of May, the catch numbering 1,212 roe shad and 1,003 bucks, valued locally at $423. That season was unusually backward and short and the fish remarkably scarce.

CHESTER RIVER.

Chester River is the second largest stream entering the Chesapeake Bay on the east, being surpassed in size only by the Choptank. It is navigable for vessels of 10 feet draft to Chestertown, 26 miles from its mouth, and for 3 or 4 feet draft about 10 miles farther. The width ranges from 2 or 3 miles near the mouth to 150 feet near Millington, at the head of navigation. The shad fisheries are prosecuted from the mouth of the river to the headwaters, but the catch is most numerous in the pound nets set near the mouth and in the stake nets from Chestertown to Millington. Of the total yield in 1896, 19,584 were taken by fishermen living in Kent County and 33,923 by fishermen from Queen Anne County.

The stake nets are set from Quaker Neck to Millington, the number of boats engaged in this fishery being 63, requiring 109 men to operate them. The nets measure from 20 to 50 yards in length and 30 to 45 meshes deep, with 5 to 5½ inch mesh, the aggregate length of the 178 nets used in 1896 being 7,020 yards. The season began April 6 and closed about May 25, the total yield being 13,440 roes and 6,150 buck shad, worth $3,223 at local valuation. A number of drift nets were formerly operated in Chester River, but they have gradually been superseded by stake nets, only 2 being reported for 1896, both operating at Chestertown.

Shad seines are used on the Chester River between Island Creek and Crumpton, 14 being employed in 1896, of which 5 were operated on the Queen Anne shore below Chestertown, the same number by men living at Chestertown, and 4 in the vicinity of Crumpton. There were also 3 seines at Queenstown, which took a very few shad. These seines measure from 400 to 150 yards in length, with 2 to 3 inch mesh, the aggregate length of the 17 being 3,835 yards. They were operated by 65 men, and in the season lasting from the middle of March to the end of May caught 3,874 roe and 6,059 buck shad, with a local valuation of $1,526.

The principal pound-net fishery of Chester River is located near the mouth of the river on both sides of the channel. On the southern shore, between Love Point and the Narrows, there were 11 pound nets in 1896, the value approximating $1,570. The mesh was 2½ inches, and the season for shad extended from the last week of March to the 1st

of June. The yield numbered 5,080 roes and 8,610 bucks, and was worth $1,943.

On the north shore of the river, between Eastern Neck Island and Swan Point, there were 51 nets set in 20 strings, the largest string containing 9 nets, but most of them with only 1 net each. These nets were much smaller than those on the Kent Island shore, the value of the 51 being only $3,240, and the catch of shad numbered 2,314 roes and 2,500 bucks, valued locally at $470. The yield of alewives during the same year was 768,000, worth $1,530. There were pound nets also at Chestertown, Quaker Neck, and Crumpton, the total numbering 19, worth $705. The catch of shad was 1,165 roes and 1,660 bucks, worth $413, making a total of 21,319 shad, valued at $2,826, taken in Chester River pound nets. In addition to shad, these nets take large quantities of alewives, perch, striped bass, catfish, etc.

The numerous fyke nets below Chestertown take many alewives and a few shad, the latter species being merely an incidental catch. The 83 fyke nets on the river in 1896 caught 2,390 shad, of which 1,440 were bucks and 950 were roes. This river ranks second among Maryland rivers in the number of shad taken in fyke nets, being surpassed only by the Nanticoke. The surplus of Chester River shad, after supplying the local demand, is sent to Baltimore and Philadelphia, good shipping facilities existing to those points by both steamer and rail.

SASSAFRAS AND ELK RIVERS.

Sassafras River.—In this tidal stream, 18 miles long, there are comparatively few shad, the great abundance of fresh water coming down from the Susquehanna attracting them past the mouth of this river. A few are obtained each year in pound nets set for alewives, perch, striped bass, etc. In 1896 there were 31 pound nets, worth $1,810, and the shad taken numbered 230 roes and 1,060 bucks, worth $166.

Elk River.—Elk River rises in Chester County, Pa., and enters Chesapeake Bay near the northern extremity, having a total length of 35 miles. From Chesapeake Bay to Elkton, the head of navigation, the river is a broad estuary three-fourths of a mile wide and 16 miles in length. There are no professional shad fisheries in Elk River, but a few shad are taken in the large number of pound nets set for alewives and other species. These nets are set on both sides of the channel from the mouth to Plum Point, near the head of the river. Those near the mouth take the largest quantity of shad, 100 or more being taken in each net, whereas few of the individual nets in the upper half take over 25 shad. The pound nets in 1896 numbered 139, worth $8,020, requiring 41 boats and 85 men to operate them. Shad were taken from March 20 to the end of May, the yield of this species being 1,629 roes and 3,615 bucks, valued locally at $637. The yield of alewives was 2,327,000 in number, but this represented only a portion of the quantity that could have been secured had there been a satisfactory market for them.

THE SHAD FISHERIES OF DELAWARE.

The shad fisheries of Delaware are prosecuted from Nanticoke River, Delaware River, Delaware Bay, and small tributaries entering them, as appears from the following series of tables:

Statement, by water areas, of the number of persons employed in each branch of the shad fisheries of Delaware in 1896.

Waters.	Fishermen.					Total, exclusive of duplication.
	Drift-net.	Stake-net.	Seine.	Pound-net.	Bow-net.	
Nanticoke River	72		50	2		120
Broad Creek	22		10			32
Delaware Bay	46	14		4		64
Broadkiln Creek	15		49			64
Mispillion Creek	60		16			76
Murderkill Creek	20		20		16	56
St. Jones Creek			24			24
Leipsic Creek	10		15			25
Duck Creek			22			22
Delaware River	164		22			186
Appoquinimink Creek			6			6
Christiana Creek	6		18			24
Total	415	14	252	6	16	699

Statement of the boats, apparatus, etc., employed in the shad fisheries of Delaware in 1896.

Waters.	Boats.		Drift nets.			Stake nets.		
	No.	Value.	No.	Length.	Value.	No.	Length.	Value.
				Yards.			*Yards.*	
Nanticoke River	47	$546	85	7,184	$1,195			
Broad Creek	13	154	22	1,540	325			
Delaware Bay	32	1,505	24	13,540	1,430	7	2,700	$240
Broadkiln Creek	32	335	13	600	43			
Mispillion Creek	58	1,280	50	2,500	400			
Murderkill Creek	34	340	20	500	60			
St. Jones Creek	6	100						
Leipsic Creek	14	140	10	250	30			
Duck Creek	6	120						
Delaware River	97	11,005	81	30,767	9,460			
Appoquinimink Creek	2	30						
Christiana Creek	9	90	4	480	28			
Total	350	15,645	309	107,361	12,971	7	2,700	240

Waters.	Seines.			Pound nets.		Bow nets.		Shore property, value.	Total value.
	No.	Length.	Value.	No.	Value.	No.	Value.		
		Yards.							
Nanticoke River	10	1,674	$825	2	$60			$2,830	$5,456
Broad Creek	2	296	145					280	904
Delaware Bay				2	325			2,200	5,700
Broadkiln Creek	18	1,580	370					1,630	2,378
Mispillion Creek	4	320	100					1,500	3,280
Murderkill Creek	6	480	150			10	$40	1,350	1,940
St. Jones Creek	6	500	150					400	650
Leipsic Creek	4	320	125					300	595
Duck Creek	6	427	150					225	495
Delaware River	4	2,250	1,050					857	22,372
Appoquinimink Creek	2	160	50					100	180
Christiana Creek	6	300	72						190
Total	68	8,307	3,187	4	385	10	40	11,672	44,140

Statement showing the yield in each branch of the shad fisheries of Delaware in 1896.

Waters.	Drift nets.		Stake nets.		Seines.		Pound nets.		Bow nets.		Total.	
	No.	Value.	No.	Val.	No.	Val.	No.	Val.	No.	Val.	No.	Value.
Nanticoke River	22,760	$2,235			19,782	$1,803	280	$34			42,832	$4,072
Broad Creek	6,710	690			2,925	393					9,635	1,083
Delaware Bay	43,220	7,765	4,200	$672			100	19			47,520	8,456
Broadkiln Creek	2,695	387			13,805	2,139					16,500	2,526
Mispillion Creek	47,500	9,726			3,180	643					50,680	10,369
Murderkill Creek	3,500	693			2,900	569			2,300	$445	8,700	1,707
St. Jones Creek					4,060	507					4,060	507
Leipsic Creek	1,700	260			1,098	160					2,798	420
Duck Creek					1,500	240					1,500	240
Delaware River	278,857	39,080			2,012	261					280,869	39,341
Appoquinimink Creek					350	55					350	55
Christiana Creek	600	100			2,300	384					2,900	484
Total	407,542	60,936	4,200	672	53,922	7,154	380	53	2,300	445	463,344	69,260

NANTICOKE RIVER.

Most of the eastern tributaries of Chesapeake Bay have their sources in the State of Delaware, yet Nanticoke River is the only one which penetrates that State sufficiently far to maintain shad fisheries within the limits of Delaware. The general physical characteristics of this stream have already been described in the chapter on the shad fisheries of Maryland. The portion situated in Delaware is small, the distance from the State line to Seaford, the head of navigation, being only 8 miles. Above Seaford the river is very narrow and shallow and soon terminates in the swamps of Sussex County. The shad fisheries of the Delaware section of Nanticoke River are prosecuted by means of drift nets and seines. The former are used from the Maryland line to Seaford, the principal fishing centers being Seaford and Woodland, while seines are operated from 2 miles below Woodland to 2 miles above Seaford.

The catch of shad by these forms of apparatus in 1896 numbered 29,470 and 22,717, respectively, while 280 were taken incidentally in pound nets, making a total yield of 52,467 shad in this section of Nanticoke River.

The drift nets range from 70 to 90 yards in length, 49 to 55 meshes deep, with $5\frac{1}{2}$ to $5\frac{3}{4}$ inch mesh. The season now begins about March 20 and ends during the first or second week in May, being somewhat shorter during recent years than formerly. The laws of Delaware interdict the taking of shad in this river after May 31 of each year. In the vicinity of Seaford the water is so clear that all drifting must be done at night, whereas at Sharptown and below fishing is done principally during the day. In 1896 there were 36 boats engaged in drifting in this section of the Nanticoke, using 85 nets, aggregating 7,184 yards in length, and manned by 72 men. The largest catch by any one boat in one day was 148 shad, and the catch during the season ranged from

400 to 1,700 per boat, the total yield numbering 12,020 roe shad and 10,740 bucks, for which the fishermen received $2,235.

Haul seines are used only in the extreme upper limits of the river, above the Maryland border line. From that point to 2 miles above Seaford there are 10 seines, measuring from 125 to 200 yards in length, 20 to 30 feet in depth, with $2\frac{1}{4}$ to $2\frac{1}{2}$ inch mesh. Five men are required at each fishery, and the beaches rent usually for about $15 annually. The season extends from the second week of March to the second or third week of May, and the catch by each seine usually ranges from 200 to 3,000 shad. The aggregate catch by the 10 seines in 1896 was 8,702 roe shad and 11,090 bucks, valued locally at $1,803.

Broad Creek.—This creek is a branch of Nanticoke River, joining that stream a short distance above the Maryland line. It penetrates the swamps of southern Delaware, and is navigable a distance of 8 miles, to Laurel. Its shad fisheries are of local importance only, the annual yield approximating 10,000, obtained by means of drift nets and seines which differ in no particular from those used on the upper portion of the Nanticoke. In 1896 there were 11 drift-net boats and two seining crews, and the catch aggregated 9,635 shad, of which 6,710 were obtained by drift nets and 2,925 by seines.

DELAWARE BAY AND RIVER.

The shad fisheries prosecuted in Delaware Bay by residents of the State of Delaware are very much less extensive than those carried on by citizens of New Jersey, and the same statement is applicable to Delaware River, although the difference in the latter is not so great. The residents of the two States fish generally on the same grounds, with similar forms of apparatus, depend on the same markets, and their interests are identical in nearly every particular. It is therefore most convenient to describe the fisheries of the two States in the same chapter, and as those prosecuted from the New Jersey shore are by far the most important the fisheries of both the bay and river will be described in the chapter relating to that State. It will suffice to state in this connection that in 1896 47,520 shad were taken in Delaware Bay and 280,869 in Delaware River by residents of Delaware, the value aggregating $47,797.

The principal fishing centers on the river are Newcastle, Delaware City, Wilmington, and Port Penn, while on the bay the principal centers are Bombay Hook and Bowers Beach.

There are a number of small streams tributary to Delaware Bay and situated entirely within this State which yield a number of shad each year, the most important being Broadkiln, Mispillion, Murderkill, St. Jones, Leipsic, Duck, Appoquinimink, and Christiana creeks. They all rise in the central and western part of Delaware and flow in a general easterly direction to their entrance into the bay. They are short, the longest barely exceeding 25 miles, and are tidal nearly to their source. The fisheries of each will be briefly noted.

Broadkiln Creek.—This creek is situated in Sussex County and empties into Delaware Bay a short distance above the breakwater at Lewes. It is nearly 20 miles long, navigable to Milton, a town of 1,200 inhabitants, about 14 miles from the mouth. According to Dr. Shortlidge, formerly fish commissioner of Delaware, shad were not caught in Broadkiln Creek previous to plantings of fry made there about eight years ago. They are now taken in some abundance by means of seines and drift nets. The run in 1896 was smaller than usual, in 1895 it was fair, while the catch in 1892 was the best on the creek. In 1896, 18 seines were used, with an aggregate length of 1,580 yards, and worth \$370. The catch of shad numbered 6,185 roes and 7,620 bucks, with a local valuation of \$2,139. A State regulation makes it "unlawful for any person or persons to make more than one haul on the ebb tide and one haul on the flood tide for the taking of shad in Broadkiln River, or to use the rattler, which is made to scare the shad, or to use anything that might be conceived of to drive the shad," and that the seine shall not remain across the river longer than one hour on each tide, but it does not appear that these regulations are enforced. The drift nets numbered 13, with an aggregate length of 600 yards, and a valuation of \$43, and the catch numbered 1,033 roes and 1,662 bucks, worth \$387 at local prices.

Mispillion Creek.—This is a narrow, tortuous, sand-hill creek, entering Delaware Bay about 17 miles northwest of Cape Henlopen. Near its mouth it averages 80 yards in width, and in the vicinity of Milford, the head of navigation, 18 miles from the mouth, the average width is about 30 yards. The apparatus used for taking shad are drift nets and a few seines. The former measure 50 yards in length, with 5¼-inch mesh, and require the services of one boat and one or two men each. Most of the 60 drift-net fishermen live at Milford, and they fish between that point and 14 miles below. The number of nets employed in 1896 was 50, the catch by which is reported at 26,000 roe shad and 21,500 bucks. Four shad seines were used on the Mispillion in the vicinity of Milford, averaging 80 yards in length, with 2-inch mesh, and requiring the services of 4 men each. The catch of shad numbered 3,180, about equally divided between roes and bucks, with a local value of \$643.

Murderkill Creek.—This creek is navigable from the mouth to Quillen Landing, 5 miles above Fredericka and about 12½ miles from Delaware Bay. Its shad fisheries are of small extent, confined to the use of a few drift nets, seines, and bow nets by men living at Fredericka. The seines used numbered 6, with an aggregate length of 480 yards, the yield of shad approximating 2,900, worth \$569, of which 1,700 were roes. Twenty drift nets were used during the same year, catching 3,500 shad, worth \$693, of which about three-fifths were roes. The Murderkill is the only river in Delaware from which the use of bow nets is reported. The catch by the 10 nets was reported at 1,300 roe shad and 1,000 bucks, worth \$445, making an aggregate of 8,700 as the total yield in 1896.

St. Jones Creek.—St. Jones Creek is a tidal stream, 40 miles in length, which empties into Delaware Bay immediately above the entrance of Murderkill Creek and 75 miles below Philadelphia. It is navigable for vessels of 6-foot draft to Lebanon, 12 miles above the mouth; thence 5 feet can be carried a distance of 9 miles to Dover, the head of navigation and the capital of the State. The shad fisheries are limited to the use of haul seines at Lebanon, Cherrytree Landing, and Dover. These seines are each from 80 to 100 yards in length, with $2\frac{1}{4}$ to $2\frac{1}{2}$-inch mesh, requiring 4 men each. They had a fairly good season in 1896, the catch in the six seines numbering 1,656 roe shad and 2,404 bucks, worth $507. There is a State interdiction against placing "any net, seine, or other device used in fishing in or across St. Jones River on or during any flood tide."

Leipsic Creek.—Leipsic Creek differs little from the other small creeks of this State, and its shad fisheries call for no special description. A few drift nets and seines are used between the mouth of the creek and Leipsic, 10 drift nets being employed in 1896, catching 900 roe shad and 800 bucks, and 4 seines caught 500 roes and 598 bucks—a total of 2,798 shad, worth $420.

Duck Creek.—This stream is narrow and winding, 15 miles in length, and empties into Delaware Bay $5\frac{1}{2}$ miles above Bombay Hook Point. In 1896, 14 fishermen from Smyrna, in Kent County, used 4 seines, each 80 yards in length, with $2\frac{1}{4}$-inch mesh. From Walker, in Newcastle County, 8 men used 2 seines, each 53 yards in length. The catch by the former approximated 1,000 shad, of which two-thirds were roe; and the catch by the Walker fishermen was about one-half as large, with the same proportion of roes and bucks.

Appoquinimink Creek.—This is a tidal stream, 20 miles in length, lying altogether in Newcastle County, and emptying into Delaware River 5 miles below Port Penn and 46 miles below Philadelphia. It is navigable for vessels of 7-foot draft to Odessa, a town of 500 inhabitants, 9 miles from the mouth. Two seines, each 80 yards in length, with $2\frac{1}{4}$-inch mesh, were used in 1896 by 6 men from Odessa. The catch of shad was small, numbering only 350, of which nearly 60 per cent were roes.

Christiana Creek.—For purposes of navigation this creek is the most important one in Delaware, as it forms the harbor of Wilmington. It is navigable to Wilmington, a distance of 8 miles, and above that point it is crossed by several dams for generating water power. Six seines were used in 1896, averaging 50 yards in length, with $2\frac{1}{2}$-inch mesh. Their catch is reported at 2,300 shad, of which two-thirds were roes. Four drift nets were also used, each 120 yards long, with $5\frac{1}{4}$-inch mesh. They caught 400 roe shad and 200 bucks, making a total of 2,900 shad, worth $484, taken during the year herein reported.

THE SHAD FISHERIES OF PENNSYLVANIA.

The shad fisheries of Pennsylvania are confined to the Susquehanna River and to the Delaware Bay and River and their tributaries. The following series of tables shows the extent of those fisheries in detail:

Statement, by water areas, of the number of persons employed in the shad fisheries of Pennsylvania in 1896.

Waters.	Number of fishermen.					Shoresmen.	Transporters.	Total.
	Drift-net.	Seine.	Bow-net.	Spear.	Total.			
Susquehanna River:								
Below Columbia dam	....	286	51	....	337	....	....	337
Above Columbia dam	....	79	....	....	79	....	....	79
Juniata River	....	12	....	....	12	....	....	12
Delaware Bay	11	....	....	....	11	....	....	11
Delaware River:								
Below Scudder Falls	340	149	....	....	489	....	....	489
Above Scudder Falls	2	155	....	30	187	16	2	205
Total	353	681	51	30	1,115	16	2	1,133

Statement, by water areas, of the boats, apparatus, etc., employed in the shad fisheries of Pennsylvania in 1896.

Waters.	Boats.		Drift nets.			Seines.		
	No.	Value.	No.	Length.	Value.	No.	Length.	Value.
Susquehanna River:				*Yards.*			*Yards.*	
Below Columbia dam	152	$3,714	....	....	....	33	6,360	$2,345
Above Columbia dam	29	777	....	....	....	16	2,260	1,190
Juniata River	2	30	....	....	....	2	170	135
Delaware Bay	10	750	5	6,000	$725	....	....	....
Delaware River:								
Below Scudder Falls	223	14,682	167	64,670	10,268	15	5,300	5,035
Above Scudder Falls	52	1,387	1	100	35	30	5,215	3,580
Total	468	21,340	173	70,770	11,028	96	19,305	12,285

Waters.	Bow nets.		Spears.		Shore property.	Total value.
	No.	Value.	No.	Value.		
Susquehanna River:						
Below Columbia dam	51	$185	....	....	$2,655	$8,899
Above Columbia dam	....	....	....	....	60	2,027
Juniata River	....	....	....	....	55	220
Delaware Bay	....	....	....	....	....	1,475
Delaware River:						
Below Scudder Falls	....	....	....	....	20,596	50,581
Above Scudder Falls	....	....	30	$23	13,085	18,110
Total	51	185	30	23	36,451	81,312

Statement, by water areas, of the yield of shad in Pennsylvania in 1896.

Waters.	Drift nets.		Seines.		Bow nets.		Spears.		Total.	
	No.	Value.	No.	Value.	No.	Value.	No.	Value.	No.	Value.
Susquehanna River:										
Below Columbia dam	....	....	53,706	$8,120	10,500	$1,893	....	....	64,206	$10,013
Above Columbia dam	....	....	5,693	1,696	....	....	....	....	5,693	1,696
Juniata River	....	....	700	287	....	....	....	....	700	287
Delaware Bay	18,600	$1,655	....	....	....	....	....	....	18,600	1,655
Delaware River:										
Below Scudder Falls	277,204	54,670	152,195	14,795	....	....	....	....	429,399	49,465
Above Scudder Falls	1,200	200	96,041	15,589	....	....	5,400	$540	102,641	16,329
Total	297,004	56,525	308,335	40,487	10,500	1,893	5,400	540	621,239	79,445

SUSQUEHANNA RIVER.

Susquehanna River is situated partly in Maryland and New York, but principally in Pennsylvania, traversing that State from its northern to its southern border. Its source is in Otsego Lake, New York, whence it flows a distance of 422 miles to its entrance into Chesapeake Bay. On account of the numerous rapids and the shoalness of the water, the river is not navigable except for skiffs in short reaches. It differs from most streams on the Atlantic coast north of Cape Lookout in that it maintains fluvial characteristics quite to its mouth and crosses the fall line very near its entrance into Chesapeake Bay, only the extreme southern end being tidal. From the mouth to Columbia, a distance of 43 miles, the width varies from a few hundred yards to something over a mile, and the channel is dotted with islands and rocks. The fall in this length is considerable, being 224 feet for the 43 miles, an average of over 5 feet per mile, resulting in numerous rapids but no abrupt falls of any moment. Aside from the large quantity of drift nets and seines near the mouth, the first serious obstruction to the ascent of shad is at Columbia, where the stream is crossed by a dam 6,800 feet long and 7 or 8 feet high, built about 1835 for the purpose of feeding the Susquehanna canal. This dam has been the principal cause of the destruction of the up-river fisheries, and its existence has naturally led to much contention between the fishermen and the owners of the dam, a brief account of which is given on pp. 225–226. Breaks frequently exist in this obstruction, permitting some shad to pass above it.

Forty miles above Columbia the Susquehanna receives its second largest tributary, the Juniata, a stream 100 miles in length, the shad fisheries of which were formerly of considerable local importance. The second dam on the Susquehanna is at Clark Ferry, just above the entrance of the Juniata, the structure being 7 feet high and nearly 2,000 feet long. At Sunbury, 38 miles above Clark Ferry, there is another canal dam 2,600 feet long and 7½ feet high. Immediately above Sunbury the Susquehanna receives its principal tributary, the West Branch, which flows a distance of 175 miles before its union with the Susquehanna, and which is obstructed by numerous dams. The Nanticoke dam, 7 miles below Wilkesbarre and 174 miles from Havre de Grace, is the fourth dam on the Susquehanna and has had very injurious effect on the shad fisheries. This structure, completed in 1830, is of cribwork, 900 feet long and 6 feet high above low water. There are a dozen or more old fish-dams between Nanticoke dam and the New York line. The fall in this length is slight, averaging scarcely more than 2 feet per mile. At Binghamton, N. Y., 318 miles from the mouth of the river, there is a cribwork dam 450 feet long and 5½ feet high at low water, extending entirely across the stream. Above Binghamton there are several primitive crib dams, producing falls of 3 to 10 feet.

In the early part of the present century, before the construction of the dams above enumerated, the shad fisheries of the Susquehanna were among the most important on the Atlantic coast, extending from the

mouth to some distance above the New York State line. But since 1835 they have been confined almost exclusively to that portion of the river lying below the Columbia Dam. The yield between Columbia and the Maryland line in 1896 numbered 25,672 roes and 38,534 bucks, of which 21,492 roes and 32,214 bucks were taken in seines and 4,180 roes and 6,320 bucks in bow nets. Thirty-three seines were used, of which 14 were at Washington Borough, 7 at East Prospect, and 8 at Columbia. The aggregate length of these seines was 6,360 yards and the value $2,345. The catch in 1896 was not up to the usual quantity. During the early part of the season the water was very high and in the latter part it was unusually low, thus shortening the season at each end. The bow nets used in the Susquehanna below Columbia are similar to those in the Maryland section of the river. They are worth from $3 to $5 and require one man to each net. They were used at the following places in 1896: McCall's Ferry, 16 nets; Fite's Eddy, 12; Creswell, 8; Long Level, 5, and Safe Harbor, 10, making a total of 51 nets.

The researches of the Wyoming Historical and Geological Society show that above the forks at Sunbury, in the early part of the present century, there were 40 fishing shores, some of which were worth $1,000 annually, the average value being about $300. There is an apparently trustworthy record of the capture of 9,997 shad at a single haul of a seine at Fish Island, near Wilkesbarre. It is reported that just below Nanticoke 3,800 shad were taken in one night, and at Monocacy Island 2,800 were taken at a single haul. At the Sterling Island fishery "over 2,000 were caught in one day in five hauls." These large catches were, of course, exceptional and possibly somewhat overrated, but they serve to show that the yield was very great. The same society estimates the annual value of the shad catch at the 40 fisheries above noted to have been at least $12,000. At an average of 8 cents each this would make 150,000 shad. The catch on the West Branch and the Juniata combined was probably equally large, and on the main river, between Sunbury and the Maryland line, the yield was doubtless much greater, making a total of at least 500,000 shad caught each year in that portion of the Susquehanna located in Pennsylvania. This abundance continued till the construction of dams on the Susquehanna during the Thirties, the most injurious being those at Columbia, Clark Ferry, Sunbury, and Nanticoke. The Columbia dam, being nearest the mouth of the river, naturally drew to it the obloquy of those interested in the destroyed up-river fisheries, that obstruction being regarded as the prime cause of all the difficulty.

The charter to the canal company required that a rafting channel should be left in the Columbia dam. Three years after its construction the State legislature directed that the company should build therein a sluice not less than 100 feet wide, with an ascent of 1 foot in 5, to promote the passage of fish. It does not appear that the company satisfactorily complied with this mandatory act, nor with a similar one

enacted in 1851, yet in 1863 the State formally acknowledged the dam as satisfactory. The hostile sentiment among the up-river residents increased, culminating in a mass convention at Harrisburg, composed of four or five hundred delegates, which resulted in the passage of an act by the legislature then in session requiring that the several companies owning or interested in dams on the Susquehanna should erect, within six months thereafter, such sluices or other devices as would permit the free passage of shad and other fish up that stream.

In compliance with this enactment the canal company owning the dam at Columbia, selecting a point about a quarter of a mile from the western bank, where shad were accustomed to gather in the greatest number during the season, removed a 40-foot section of the dam and in that space built a new subdam, the top of which was about level with the water below. The lower slope of the subdam was placed at an inclination of 1 in 15, and the sides of the aperture in the main dam were dentated, so as to promote the formation of eddies in the current passing over the subdam. This structure did not appear to answer its purposes, and in 1873 the State made an appropriation for another fishway at that point, the designs consisting of a single trough 120 feet long by 60 feet wide, running through the dam, and about 150 feet back into the part below, with its upper end sunk 2 feet below the crest of the dam, the sides of the trough or fishway being protected by strong abutments built up on both sides. This also proved ineffectual, and in 1880 a third fishway was placed in the dam, consisting simply of an opening 125 feet wide, this plan being chosen because it conformed to a break in the dam, experience having shown that shad passed through such an opening more readily than through any fishway that had been constructed. In 1886 a fourth fishway was constructed on the site of the one built by the canal company in 1866.

While shad do pass above the dam, yet during recent years few have been caught above Columbia, except when breaks exist in the obstruction. This was the case in 1873, 1877, 1895, 1896, and possibly during some intervening seasons. The break in 1895 occurred in the spring and many shad ascended as far as Clark Ferry. The men along the river were not prepared for their coming and few fish were caught. The break was not repaired, and in 1896 some few seines were used which did fairly well in those places where the bottom was sufficiently clean for hauling. The principal places above Columbia dam where shad were caught are Bainbridge, Marsh Run, Newmarket, McCormack Island, and Duncannon on Susquehanna River, and Newport on the Juniata. Seines were the only apparatus employed, and the number of these between Columbia dam and Clark Ferry dam was 14, with 2 on the Juniata near Newport. The length ranged from 250 yards down to 80, with $4\frac{1}{4}$ to $5\frac{1}{2}$ inch mesh. The catch in the 14 seines on the Susquehanna numbered 2,417 roe shad and 3,276 bucks, valued locally at $1,696. The 2 seines at Newport, on the Juniata, caught 280 roe and 420 buck shad, worth $287, making a total of 6,393 shad taken

above the Columbia dam in 1896. The fishing season for shad on the Susquehanna and the Juniata rivers is limited "from Monday at sunrise till Saturday at sunset of each week from March 15 to June 25 of each year." In 1873, when there was a large break in Columbia dam, 9,000 shad were taken in one of the Newport seines; in 1876, when there were no breaks, 511 shad were caught, and in 1877, when there were two breaks, one 20 feet wide and one 35 feet wide, 826 shad were taken. If the break in the Columbia dam is not repaired, the catch above that point will doubtless continue to increase, as the fishermen will make preparation for them.

The shad fishermen on the upper Susquehanna have three principal complaints, the first and most general one being the existence of the Columbia dam. The second complaint is that in Juniata River below the Millertown dam, and to some extent in Susquehanna River, there are a number of rough V-shaped stone breakwaters, similar to those used in the Maryland section of the river, but having a small-meshed net stretched across at the apex instead of the usual finger or fall trap. This contrivance is intended for the capture of eels, but in the late summer and early fall large quantities of young shad are caught and destroyed. The seine fishermen near the Columbia dam are charged with a practice known locally as "shingling," which consists in attaching new shingles to weights by means of short lines and placing them in the current of water passing through the breaks in the dams. The current causes the anchored shingle to revolve rapidly, scaring the fish and thus preventing them from passing above the broken dam.

DELAWARE RIVER.

The shad fisheries prosecuted in Delaware River by residents of Pennsylvania are of importance, the catch averaging at least half a million, but the operations of the New Jersey fishermen are much greater. It is desirable to describe the fisheries of both sides of the river at the same time, and, those on the New Jersey side being the more numerous, an account for the entire river will be given in the chapter relating to that State. In 1896 there were 705 residents of Pennsylvania employed in the shad fisheries of Delaware River and Bay, using 173 drift nets, 45 seines, and 30 spears, and taking 550,640 shad, worth $67,449, as appears in the tables on page 223.

Schuylkill River.—The Schuylkill formerly yielded many shad. William Penn mentioned in one of his letters that "600 shad had been taken with one sweep of the seine" in that river. In 1818 the Schuylkill Navigation Company built two large dams across the stream, one at Shawmont and the other at Reading. In 1820 the city of Philadelphia built the large dam at Fairmount for water-supply purposes, thus completely destroying the shad fisheries above that point. But the fishing below the Fairmount dam was remunerative until the building of the gas works a few years later, the refuse from which causes shad to avoid this river.

THE SHAD FISHERIES OF NEW JERSEY.

The extent by water areas of the shad fisheries of New Jersey is presented in the following series of three tables, showing (1) the number of persons employed; (2) the boats, apparatus, etc., used, and (3) the quantity and value of the catch.

Statement showing, by water areas, the number of persons employed in the shad fisheries of New Jersey in 1896.

Waters.	Number of fishermen.				Total, exclusive of duplication.	Shoresmen.	Transporters.	Total.
	Gill-net.		Seine.	Fyke-net.				
	Drift.	Stake.						
Delaware Bay	565		12		577		3	580
Delaware River below Scudder Falls	1,077		312		1,389	35	35	1,459
Delaware River above Scudder Falls	80		176		256			256
Cohansey Creek	32		20		52			52
Alloway Creek			2		2			2
Salem Creek	30				30			30
Raccoon Creek			5		5			5
Mantua Creek			2		2			2
Big Timber Creek			19		19			19
Jenkins Sound			2		2			2
Ludlam Bay			10		10			10
Manasquan River		8	14	10	28			28
Sandy Hook Bay		54			54			54
Raritan Bay		73			73			73
Raritan River				1	1			1
New York Bay				25	25			25
Hudson River		176			176			176
Total	1,784	311	574	36	2,701	35	38	2,774

Statement showing, by water areas, the boats, apparatus, etc., employed in the shad fisheries of New Jersey in 1896.

Waters.	Boats.		Drift nets.			Stake nets.		
	No.	Value.	No.	Length.	Value.	No.	Length.	Value.
				Yards.			*Yards.*	
Delaware Bay	236	$29,080	230	271,200	$42,775			
Delaware River below Scudder Falls	606	60,950	538	262,547	49,455			
Delaware River above Scudder Falls	101	3,122	40	6,060	913			
Cohansey Creek	45	450	25	2,500	625			
Alloway Creek	1	20						
Salem Creek	15	300	15	4,500	750			
Raccoon Creek	4	50						
Mantua Creek	1	30						
Big Timber Creek	4	135						
Jenkins Sound	1	10						
Ludlam Bay	5	50						
Manasquan River	12	140				8	400	$40
Sandy Hook Bay	26	930				107	16,840	3,900
Raritan Bay	40	821				982	24,304	4,256
Raritan River	1	60						
New York Bay	13	855						
Hudson River	69	4,905				1,530	15,282	7,935
Total	1,180	101,908	848	546,807	94,518	2,627	56,826	16,131

Statement of boats, apparatus, etc., employed in New Jersey shad fisheries—Continued.

Waters.	Seines.			Fyke nets.		Value of shore property.	Total investment.
	No.	Length.	Value.	No.	Value.		
		Yards.					
Delaware Bay	2	850	$425			$24,040	$96,320
Delaware River below Scudder Falls	21	9,378	9,080			65,736	185,221
Delaware River above Scudder Falls	34	5,950	4,023			21,447	29,505
Cohansey Creek	10	600	300				1,375
Alloway Creek	1	100	45				65
Salem Creek							1,050
Raccoon Creek	2	210	110				160
Mantua Creek	1	100	50				80
Big Timber Creek	4	380	370				505
Jenkins Sound	1	50	15				25
Ludlam Bay	5	250	100				150
Manasquan River	6	1,322	145	20	$100	55	480
Sandy Hook Bay							4,830
Raritan Bay							5,077
Raritan River				11	550		610
New York Bay				214	1,314	275	2,444
Hudson River						1,175	14,015
Total	87	19,190	14,663	245	1,964	112,728	341,912

Statement by apparatus of the yield of shad in New Jersey in 1896.

Waters.	Drift nets.		Stake nets.		Seines.	
	No.	Value.	No.	Value.	No.	Value.
Delaware Bay	1,037,001	$94,576			700	$74
Delaware River below Scudder Falls	1,486,730	148,561			327,430	25,813
Delaware River above Scudder Falls	42,800	4,284			108,934	16,805
Cohansey Creek	11,850	1,542			10,000	1,050
Alloway Creek					300	35
Salem Creek	8,000	800				
Raccoon Creek					4,800	464
Mantua Creek					2,000	220
Big Timber Creek					10,400	728
Jenkins Sound					40	16
Ludlam Bay					50	12
Metedeconk River and Barnegat Bay					*a* 150	38
Manasquan River			200	$50	625	312
Sandy Hook Bay			6,600	1,320		
Raritan Bay			15,675	3,409	*a* 1,010	223
Hudson River			168,800	24,316		
Total	2,586,381	249,763	191,275	29,095	466,439	45,790

Waters.	Pound nets.		Fyke nets.		Total.	
	No.	Value.	No.	Value.	No.	Value.
Delaware Bay					1,037,701	$94,650
Delaware River below Scudder Falls					1,814,160	174,374
Delaware River above Scudder Falls					151,734	21,089
Cohansey Creek					21,850	2,592
Alloway Creek					300	35
Salem Creek					8,000	800
Raccoon Creek					4,800	464
Mantua Creek					2,000	220
Big Timber Creek					10,400	728
Jenkins Sound					40	16
Ludlam Bay					50	12
Metedeconk River and Barnegat Bay					150	38
Manasquan River			1,500	$375	2,325	737
Ocean Shore	*a* 13,675	$2,715			13,675	2,715
Sandy Hook Bay					6,600	1,320
Raritan Bay	*a* 26,702	4,005	*a* 250	38	43,637	7,675
Raritan River			2,500	938	2,500	938
New York Bay			49,758	7,337	49,758	7,337
Hudson River					168,800	24,316
Total	40,377	6,720	54,008	8,688	3,338,480	340,056

a Caught incidentally in apparatus set for other species.

DELAWARE BAY AND RIVER.

The sources of the Delaware are in the high plateau of central New York, in Delaware and Schoharie counties, at an elevation of over 1,800 feet above sea level. Eighty miles below the headwaters it becomes the eastern boundary of Pennsylvania, and by a breach, known as the "Delaware Water Gap," it passes through the Kittatinny Mountains at a distance of 200 miles below its source. It crosses the escarpment line near Trenton, the head of navigation, 280 miles from its headwaters and 133 miles from the Atlantic Ocean. From Trenton to Fort Delaware, a distance of about 75 miles, it is a broad, navigable stream from ½ to 2 miles in width, supporting considerable commerce below Philadelphia. Near Fort Delaware it increases in width, and at some indefinite and much-disputed point it merges into Delaware Bay, which is merely a continuation of the estuary of the river. This body of water separates the States of Pennsylvania and Delaware from New Jersey, and the fisheries are prosecuted by the residents of those three States.

The present chapter covers all the shad fisheries of Delaware River and Bay, including those which are prosecuted by residents of Pennsylvania and Delaware, as well as those of New Jersey. These fisheries are the most extensive in America, the annual yield ranging between 3,000,000 and 4,000,000, being several times greater than on any other river on the coast. In 1896 the catch numbered 3,882,624, of which 3,003,595 were taken by residents of New Jersey, 550,640 by residents of Pennsylvania, and 328,389 by Delawareans. In describing the shad fisheries of this body of water, it is most convenient to divide it into three sections, the first covering Delaware Bay; the second, the tidewater portion of the river from the head of the bay to the fall line at Scudder Falls; and the third from the escarpment line to the head of the river. Of the total yield in these waters in 1896, 1,103,821 were caught in the bay, 2,602,628 in the tidal portion of the river from the head of the bay to Scudder Falls, and 176,175 from the section above Scudder Falls.

The following table shows the number of persons employed in each branch of the shad fisheries of Delaware Bay and River during 1896:

Branch of fishery.	Delaware Bay.	Delaware River below Scudder Falls.	Delaware River above Scudder Falls.	Total for Delaware Bay and River.
Stake-net	14			14
Drift-net	622	1,661	2	2,285
Seine	12	526	288	826
Spear			30	30
Pound-net	4			4
Shoresmen		51		51
Transporters		37		37
Total	652	2,275	320	3,247

The following table shows the boats, apparatus, etc., employed in the fisheries of Delaware Bay and River in 1896:

Designation.	Delaware Bay.			Delaware River below Scudder Falls.		
	Number.	Length.	Value.	Number.	Length.	Value.
		Yards.			*Yards.*	
Boats	278		$31,335	988		$88,762
Stake nets	7	2,700	240			
Drift nets	259	290,740	44,930	826	414,044	70,096
Seines	2	850	425	45	17,903	15,720
Pound nets	2		325			
Spears						
Shore property			26,240			93,109
Total			103,495			267,687

Designation.	Delaware River above Scudder Falls.			Total for Delaware Bay and River.		
	Number.	Length.	Value.	Number.	Length.	Value.
		Yards.			*Yards.*	
Boats	91		$2,384	1,357		$122,481
Stake nets				7	2,700	240
Drift nets	1	100	35	1,086	704,884	115,061
Seines	59	10,190	7,048	106	28,943	23,193
Pound nets				2		325
Spears	30		23	30		23
Shore property			38,612			157,961
Total			48,102			419,284

The following table shows the yield of shad in Delaware Bay and River, by each form of apparatus, in 1896:

Apparatus.	Delaware Bay.			Delaware River below Scudder Falls.		
	Number of roe.	Number of buck.	Value.	Number of roe.	Number of buck.	Value.
Stake nets	2,520	1,680	$672			
Drift nets	724,677	374,144	103,996	1,375,561	710,030	$226,595
Seines	350	350	74	285,517	231,520	44,422
Pound nets	55	45	19			
Total	727,602	376,219	104,761	1,661,078	941,550	271,017

Apparatus.	Delaware River above Scudder Falls.			Total for Delaware Bay and River.		
	Number of roe.	Number of buck.	Value.	Number of roe.	Number of buck.	Value.
Stake nets				2,520	1,680	$672
Drift nets	800	400	$200	2,101,038	1,084,574	330,791
Seines	104,610	64,965	28,841	390,477	296,835	73,337
Pound nets				55	45	19
Spears	2,160	3,240	540	2,160	3,240	540
Total	107,570	68,605	29,581	2,496,250	1,386,374	405,359

Delaware Bay.—Delaware Bay is the broadest portion of the estuary of Delaware River, forming an arm of the sea varying in width from 4 to 30 miles and is 45 miles in length, covering 600 square miles. Its northern limit is somewhat indefinite and has been the subject of considerable contention. For sake of convenience, in this report the head of the bay has been assumed to be at a line drawn from Bombay Hook on the Delaware shore to the mouth of Stow Creek on the New Jersey shore. The channel, which traverses the axis of the bay, is from 30 to 50 feet deep and from 1 to 3 miles in width, and on either side there are broad shoals or flats covered by from 5 to 20 feet of water. The water in the bay has about the same density as that in the ocean. The forms of apparatus used are drift nets, stake nets, seines, and pound nets, the first named being by far the most important and obtaining over 99 per cent of the total catch.

The following series of tables shows by States the extent of each branch of the shad fisheries of Delaware Bay during the year covered by this report:

Table showing, by States, the number of persons employed in each branch of the shad fisheries of Delaware Bay in 1896.

Branch of fishery.	Delaware.	New Jersey.	Pennsylvania.	Total.
Stake-net	14			14
Drift-net	46	565	11	622
Seine		12		12
Pound-net	4			4
Total	64	577	11	652

Table showing, by States, the boats, apparatus, etc., employed in each branch of the shad fisheries of Delaware Bay in 1896.

Designation.	Delaware.			New Jersey.		
	Number.	Length.	Value.	Number.	Length.	Value.
		Yards.			Yards.	
Boats	32		$1,505	236		$29,080
Stake nets	7	2,700	240			
Drift nets	24	13,540	1,430	230	271,200	42,775
Seines				2	850	425
Pound nets	2		325			
Shore property			2,200			24,040
Total			5,700			96,320

Designation.	Pennsylvania.			Total.		
	Number.	Length.	Value.	Number.	Length.	Value.
		Yards.			Yards.	
Boats	10		$750	278		$31,335
Stake nets				7	2,700	240
Drift nets	5	6,000	725	259	290,740	44,930
Seines				2	850	425
Pound nets				2		325
Shore property						26,240
Total			1,475			103,495

Table showing by States the yield of the shad fisheries of Delaware Bay in 1896.

Apparatus.	Delaware.			New Jersey.		
	Number of roe.	Number of buck.	Value.	Number of roe.	Number of buck.	Value.
Stake nets	2,520	1,680	$672			
Drift nets	27,586	15,634	7,765	684,692	352,309	$94,576
Seines				350	350	74
Pound nets	55	45	19			
Total	30,161	17,359	8,456	685,042	352,659	94,650

Apparatus.	Pennsylvania.			Total.		
	Number of roe.	Number of buck.	Value.	Number of roe.	Number of buck.	Value.
Stake nets				2,520	1,680	$672
Drift nets	12,399	6,201	$1,655	724,677	374,144	103,996
Seines				350	350	74
Pound nets				55	45	19
Total	12,399	6,201	1,655	727,602	376,219	104,761

The drift nets in Delaware Bay are used principally in the channel and on the edge thereof. They average over 1,100 yards each, the aggregate length of the 259 nets used in 1896 being 290,740 yards, or 165 miles, the usual size of mesh being 5½ inches. Many fishermen operating these nets live up the river, locating temporarily near the mouth of Stow and Cohansey creeks, and shipping their fish from Bay Side.

The fishing season begins about the second week of March and continues until the 1st of May, when the sturgeon fishery proves more remunerative, and many of the fishermen are attracted to that industry. Those who do not engage in the sturgeon fishery usually shorten their nets and fish for shad in the upper reaches of the river in the vicinity of Philadelphia. In the early part of the season, when the water is usually turbid, the nets may be operated during the day, but as the water becomes clearer night fishing is more profitable. Of the drift-net catch, 1,037,001 were obtained by New Jersey fishermen, 43,220 by Delawareans, and 18,600 by residents of Pennsylvania; a total of 1,098,821, valued at $103,996. The great excess of roes over bucks is noticeable, the former being 94 per cent greater than the latter, due mainly to the large mesh used in the drift nets.

The stake-net fishery in Delaware Bay is confined to the use of 7 rows on the flats on the Delaware side of the bay immediately above the mouth of Mispillion Creek, in from 6 to 10 feet of water. These strings or rows are nearly 400 yards in length, and are worth about $35 each. The catch in the 7 rows in 1896 numbered 2,520 roe shad and 1,680 bucks, valued locally at $672. Two seines, each 425 yards in length, were used on the New Jersey side of the Delaware Bay in 1896 for taking striped bass, perch, etc. These caught a few shad, the total numbering 700, about equally divided between roes and bucks.

Delaware River below Scudder Falls.—The estuary of Delaware River, from the head of Delaware Bay to the fall line just above Trenton, is, from a commercial and fishery point of view, one of the most important streams on the Atlantic coast. It varies in width from 4 miles at the lower end to a few hundred feet near Trenton, up to which point it is navigable. On the east it borders Salem, Gloucester, Camden, Burlington, and Mercer counties, N. J., and on the west it passes the shores of Newcastle County, Del., and Delaware, Philadelphia, and Bucks counties in Pennsylvania. By the compact of 1783 between the States of New Jersey and Pennsylvania, the whole surface of Delaware River from shore to shore is the dividing line between the two States as far as relates to the arrest and prosecution of offenders against the laws of either State. All fishing is interdicted after June 10 of each year, and also from sunset Saturday night until 12 o'clock p. m. Sunday of each week. The principal fishing centers are Penn Grove, Pennsville, Salem, Pedrickton, Gloucester, and Camden in New Jersey; Delaware City and Newcastle in Delaware, and Philadelphia in Pennsylvania. Drift nets and seines are the only apparatus used. Of 2,602,628 shad caught in 1896, 2,085,591 were taken by drift nets and 517,037 by seines.

The following series of tables shows the extent of each branch of the shad fisheries of this water area:

Table showing, by States, the number of persons employed in each branch of the shad fisheries of Delaware River below Scudder Falls in 1896.

Branch of fishery.	Delaware.	Pennsylvania.	New Jersey.	Total.
Drift net	164	340	1,157	1,661
Seine	22	149	355	526
Shoresmen	....	16	35	51
Transporters	....	2	35	37
Total	186	507	1,582	2,275

Table showing, by States, the boats, apparatus, etc., employed in the shad fisheries of Delaware River below Scudder Falls in 1896.

Designation.	Delaware.			Pennsylvania.		
	Number.	Length.	Value.	Number.	Length.	Value.
		Yards.			Yards.	
Boats	97	....	$11,005	223	....	$14,682
Drift nets	81	80,767	9,460	167	64,670	10,268
Seines	4	2,250	1,050	15	5,300	5,035
Shore property	....	....	857	....	....	20,596
Total	....	....	22,372	....	....	50,581

Designation.	New Jersey.			Total.		
	Number.	Length.	Value.	Number.	Length.	Value.
		Yards.			Yards.	
Boats	668	....	$63,075	988	....	$88,762
Drift nets	578	268,607	50,368	826	414,044	70,096
Seines	26	10,353	9,635	45	17,903	15,720
Shore property	....	....	71,656	....	....	93,109
Total	....	....	194,734	....	....	267,687

Table showing, by States and apparatus, the yield of shad in the Delaware River below Scudder Falls in 1896.

Apparatus.	Delaware.			Pennsylvania.		
	No. of roe.	No. of buck.	Value.	No. of roe.	No. of buck.	Value.
Drift nets	179,666	99,191	$39,080	180,823	96,381	$34,670
Seines	1,210	802	261	88,529	63,666	14,795
Total	180,876	99,993	39,341	269,352	160,047	49,465

Apparatus.	New Jersey.			Total.		
	No. of roe.	No. of buck.	Value.	No. of roe.	No. of buck	Value.
Drift nets	1,015,072	514,458	$152,845	1,375,561	710,030	$226,595
Seines	195,778	167,052	29,366	285,517	231,520	44,422
Total	1,210,850	681,510	182,211	1,661,078	941,550	271,017

The drift nets are similar to those operated in the bay, but are smaller. Indeed, it is somewhat difficult to separate the drift-net fishery of the bay from that in this portion of the river. In the early part of the season many of the fishermen operate in the upper portion of the bay and the extreme lower end of the river, and as the season advances they proceed up the river, shortening their nets when necessary. Hence the separation of the drift-net fishery of the river from that prosecuted in the bay is only approximately correct. Of the 414,044 yards of drift nets used in this section of the river in 1896, 80,767 yards, or 46 miles, were operated by 164 Delaware fishermen; 64,670 yards, or 37 miles, by 340 fishermen from Pennsylvania, and the remaining 268,607 yards, or 157 miles, by residents of New Jersey. The nets used in the lower portion of the river are much longer than those above Philadelphia, the average length of the former being about 800 yards, and of the latter 200 or 300 yards. The drift-net catch in 1896 numbered 1,375,561 roe shad and 710,030 bucks, for which the fishermen received $226,595. This gives an average catch per boat for the Delaware fishermen of 3,443 shad; for the New Jersey fishermen, 3,289, and 1,660 shad per boat for the Pennsylvania fishermen. This is reported to have been the best yield since 1893, it being 20 per cent larger than in 1895 and 30 per cent larger than in 1894.

From the head of Delaware Bay to the falls above Trenton there were 45 shad seines operated in 1896, of which 4 were in Delaware, 15 in Pennsylvania, and 26 in New Jersey. The seine fisheries in the lower part of the river below Fort Delaware take very few shad, their catch consisting principally of perch, striped bass, catfish, carp, etc., the average yield of shad in the 8 seines operated there in 1896 being less than 500 each. Above Fort Delaware the river narrows and maintains an average width of from 1 to 2 miles up to the mouth of the Schuylkill River. This stretch of the river contains 5 seine fisheries, all of which are valuable, the catch of shad in 1896 approximating 76,300, of which 25,000 were taken at the Clenmell Cove fishery, located immediately above Thompson Point, at the mouth of Clenmell Creek.

Between Eagle Point and Fisher Point, on the New Jersey side of the river and directly opposite the city of Philadelphia, there are three very valuable fisheries, which catch more shad than any other three seine fisheries in the United States. The first of these is the Howell Cove, or Fancy Hill, which yielded 65,000 shad in 1896. The seine used was 1,000 yards in length with 4⅞-inch mesh, the season extending from April 27 to June 5, and 55 men being employed. The following summary shows, for a series of years, the yield of shad at the Fancy Hill fishery:

Year.	No. of shad.	Year.	No. of shad.	Year.	No. of shad.
1818*a*	11,492	1847*b*	59,949	1869*c*	37,274
1819*a*	159,864	1848*b*	17,304	1870*c*	52,759
1820*a*	170,505	1849*b*	38,998	1871*c*	45,000
1821*a*	107,091	1865*b*	64,925	1872*c*	55,000
1822*a*	107,194	1866*c*	59,550	1873*c*	22,900
1845*b*	90,540	1867*c*	98,000	1896*c*	65,000
1846*b*	125,659	1868*c*	43,900		

a Gill nets not used during this period. *b* A few gill nets used. *c* Gill-net fishery fully established.

The second is the well-known Gloucester fishery, the yield of which in 1896 is reported at 70,000 shad. A 1,000-yard seine was used; the season extended from April 20 to May 28, and the men employed numbered 53. The following summary shows the catch of shad at this fishery in seven years:

Year.	No. of shad.	Year.	No. of shad.
1884	26,428	1892	30,500
1885	30,969	1894	50,000
1890	38,600	1896	70,000
1891	36,500		

The third of this series of valuable fisheries, known as the Pea Shore fishery, is located immediately above Camden, the seine being operated in the channel between Pettys Island and the New Jersey shore. This seine is only one-half the length of the two preceding and required only 29 men to operate it, but the reported catch of shad for 1896 is not far short of the other two, approximating 55,000, valued locally at $4,125.

Between the Pea Shore fishery and Burlington there were 5 seine fisheries in 1896, 3 of which were on the New Jersey shore and 2 on the Pennsylvania side of the river. These are of less value than the 3 fisheries opposite Philadelphia, but their yield of shad is considerable, varying from 35,000 at the Riverton fishery to 3,000 at the Dunks Ferry fishery. From Burlington to Trenton there were 11 fisheries in 1896, 7 on the Pennsylvania and 4 on the New Jersey shore, the catch ranging from 5,000 to 20,000 shad. In 1833 the Badger Island fishery, one of the 7 on the Pennsylvania side, caught 2,100 shad on April 1,

and 54,000 shad during the entire season. This fishery then rented for $1,400 per annum. In 1896 3,000 shad were caught at the Badger Island fishery.

In the rapids between Trenton and Scudder Falls dam there are 6 seine fisheries, located in the most favorable spots. Two of these are situated directly below the dam, 2 on the New Jersey shore opposite Yardley, and the remaining 2 on separate islands between that point and Trenton. The catch of shad in these seines in 1896 ranged between 1,000 and 16,000 in number.

From Scudder Falls to the headwaters.—Near Trenton the Delaware crosses the escarpment line, 133 miles from the ocean. The fall here is very slight, the descent within 7 miles being only 10 to 20 feet, according to the tide and prevalence of freshets. Six miles above Trenton, at the head of the rift known as Scudder Falls, there is a timber and stone dam 4 or 5 feet high and 800 feet or more in length, extending in a broken line across the stream, with a chute 115 feet in width for the passage of fish and rafts. This dam was constructed originally in 1835 and improved about 1869. In 1870 the fishermen brought suit in the county court at Doylestown, Pa., against the company, claiming that the change in the dam was injurious to the passage of shad. The court imposed a nominal penalty on the company, and restrained them from repairing or improving the dam. As a result, it has so deteriorated that it offers little obstruction to the passage of fish.

At Lambertville, 15 miles above Trenton, there is a stone and cribwork dam, from 3 to 10 feet high and 1,700 feet long, a chute being left for the passage of rafts. At Lackawaxen there is a canal-feeder dam just below the entrance of Lackawaxen River. This is a cribwork structure about 400 feet long and 2 feet high, with a chute 160 feet wide for rafts. During freshets the water stands several feet above the crest of this obstruction and shad ascend in some numbers to Burrows dam, in New York, about 50 miles above Lackawaxen. There are numerous minor dams at various points between Trenton and the New York line, but they do not seriously impede the upward passage of fish or downward navigation of rafts or small boats.

The shad fisheries above tide water are more extensive on the Delaware than on any other river of the United States, the catch in 1896 numbering 176,175, worth $29,581. They extend from Scudder Falls to Lackawaxen, a distance of 140 miles, but are most extensive in the stretch 40 miles above Scudder Falls dam. With the exception of one drift net operated a short distance above the falls, seines and spears are the only apparatus used in taking shad in the upper section of the Delaware. Of the 176,175 shad caught in 1896, 169,575 were taken by means of seines, 5,400 by spears, and 1,200 by the one drift net.

The legal season closes on June 15 of each year and all fishing is interdicted from sunset on Saturday to 12 o'clock on Sunday night of each week.

The following series of tables shows, by States, the extent of each branch of the shad fisheries of the Delaware River above Scudder Falls dam in 1896:

Number of persons employed.

Persons employed.	Pennsylvania.	New Jersey.	Total.
Drift-net	2		2
Seine	155	133	288
Spear	30		30
Total	187	133	320

Boats, apparatus, etc., used.

Designation.	Pennsylvania.			New Jersey.			Total.		
	No.	Length (yards).	Value.	No.	Length (yards).	Value.	No.	Length (yards).	Value.
Boats	52		$1,387	39		$997	91		$2,384
Drift nets	1	100	35				1	100	35
Seines	30	5,215	3,580	29	4,975	3,468	59	10,190	7,048
Spears	30		23				30		23
Shore property			13,085			25,527			38,612
Total			18,110			29,992			48,102

Number and value of shad caught.

Apparatus.	Pennsylvania.			New Jersey.			Total.		
	No. of roe.	No. of buck.	Value.	No. of roe.	No. of buck.	Value.	No. of roe.	No. of buck.	Value.
Drift nets	800	400	$200				800	400	$200
Seines	59,119	36,922	15,589	45,491	28,043	$13,252	104,610	64,965	28,841
Spears	2,160	3,240	540				2,160	3,240	540
Total	62,079	40,562	16,329	45,491	28,043	13,252	107,570	68,605	29,581

Most of the available locations on the Upper Delaware are occupied by seine fisheries, and as the last two or three seasons have yielded large returns several abandoned fisheries are being cleaned out and operated. Some of these fisheries are very old, having been operated continuously since the beginning of the present century. Lovett's fishery, in Bucks County, was established in 1790; Lower Dutch Neck fishery, in 1810; and Badger Island fishery, in the same county, in 1812. The yield by the 59 seines in 1896 numbered 104,610 roes and 64,965 bucks, a total of 169,575, valued locally at $28,841. This yield was unusually large, more being obtained at times than could readily be disposed of, and the price received was the lowest known on the river for several years. The large run may be due somewhat to the fact that for four or five years preceding there were heavy freshets, which restricted the fishing in the early part of the season, thus permitting the shad to reach the upper waters to spawn.

The following statement shows the annual catch since 1883 at the Taylorsville fishery, a short distance below Titusville:

Year.	No. of shad.	Year.	No. of shad.
1884	1,628	1891	955
1885	1,093	1892	960
1886	709	1893	840
1887	835	1894	1,177
1888	1,752	1895	2,300
1889	1,661	1896	2,491
1890	1,967		

Although an interdiction exists against the use of spears in taking shad on Delaware River, yet that form of apparatus was used quite extensively in 1896 at the Lackawaxen dam, 146 miles above Trenton. Some of the spear fishermen operated from rowboats, while others worked from the apron of the dam. Thirty men are reported as taking 2,160 roe shad and 3,240 bucks, worth locally about $10 per hundred.

There are several streams in New Jersey tributary to the Delaware, in most of which some shad are taken each season. Among these are Cohansey, Salem, Raccoon, Mantua, and Timber creeks, each of which will be described in succession. In other streams along this shore, such as Maurice River, Woodbury, Old Mans, Rancocas, Cooper, etc., there are a few shad taken for local use, but the fisheries are so intimately associated with the fisheries of the Delaware, or they are so small and so irregularly prosecuted, that it is not practicable to show the actual quantity taken.

Cohansey Creek.—Cohansey Creek, which enters Delaware Bay 37 miles above Cape May, is tidal as far as Bridgeton, the head of navigation, 20 miles from the mouth. At that point there is an earthen dam, 11 or 12 feet high, across the stream for developing water-power. While the fisheries of this creek are not of great extent, yet it ranks third in importance among the shad-producing streams of New Jersey, being surpassed in this particular only by the Delaware and Hudson rivers. The yield in 1896 numbered 21,850 shad, worth $2,592, of which 11,850 were taken by drift nets and 10,000 by seines.

The drift-net fishermen live at Bridgeton and Fairton. The nets used by them average 100 yards in length, with 5¼-inch mesh, costing about $25 each. In 1876 the drift nets numbered 18 and the catch of shad by them was 4,000. In 1896 25 drift nets were used by 32 fishermen, the catch numbering 7,900 roe shad and 3,950 bucks, worth $1,542. The Bridgeton fishermen operated 10 seines in 1896 at various points on Cohansey Creek, averaging 60 yards in length and requiring 2 men each. The size of mesh is from 2¼ to 4 inches, and they are hauled for carp, striped bass, alewives, etc., as well as shad. The catch of shad during the year above noted approximated 10,000, about equally divided between roes and bucks.

Salem River.—Salem River rises in the northeastern part of Salem County and discharges into Delaware River at a point about 4 miles below Fort Delaware. Fishermen from the town of Salem use drift

nets in this stream, the nets averaging 300 yards in length, with 5½-inch mesh, 2 men being required for each. Fifteen nets were used in 1896, catching about 8,000 shad, of which two-thirds were roes.

Raccoon River.—The shad fisheries of Raccoon River, which enters Delaware River opposite Marcus Hook, were limited to the use of 2 small seines, each 70 yards in length, the yield in which numbered only 4,800, of which two-thirds were bucks. The small catch was due to the shad being driven away by the dumping of mud in Delaware River just below the entrance of Raccoon River.

Mantua Creek.—This creek discharges into Delaware River about 10 miles below Philadelphia, at a point abreast of Mifflin Bar. Only 1 seine was used in 1896, 100 yards in length, with 3-inch mesh. The yield was about an average for recent years, numbering 2,000 shad, about equally divided between roes and bucks.

Big Timber Creek.—This creek, forming the dividing line between Gloucester and Camden counties, is 30 miles in length and navigable only a short distance above the mouth, yet its shad fisheries have been successfully operated for many years. Four seines are employed, each about 100 yards in length, with 3½-inch mesh; they are hauled for other species as well as shad. The catch in 1896 numbered 4,160 roe shad and 6,240 bucks, the local value being $728.

OCEAN SHORE OF NEW JERSEY.

In several of the small sounds and bays on the ocean shore of New Jersey a few shad are taken each year in the seines, stake nets, and fyke nets set for other species of fish, the total yield in 1896 numbering 2,565, valued at $803. Shad were reported from Jenkins Sound, Ludlam Bay, Barnegat Bay, Metedeconk River, and Manasquan River, the yield from each of which is shown on page 229. On the coast from Barnegat Bay to Sandy Hook numerous pound nets are operated from May 1 to October 31, in which shad are taken incidentally during May. The nets set in 1896 numbered 49, valued at $116,600, yielding 6,940 roe shad and 6,735 bucks, valued locally at $2,715, an average of 279 shad per net. This is the southernmost point on the Atlantic coast at which shad are taken in considerable numbers outside the general coast line.

SANDY HOOK BAY.

This bay, forming a part of the waterway tributary to the harbor of New York City, is separated from the ocean on the east by a narrow sand beach known as Sandy Hook. The shad fisheries are confined to the use of stake nets, which average between 150 and 160 yards in length, with from 5¼ to 6 inch mesh, and cost about $40 each. The season begins about the first week in April and usually lasts four weeks. The nets used in 1896 numbered 107, with an aggregate length of 16,840 yards and valuation of $3,900, 26 boats worth $930, and 54 men being employed. The catch was much less than usual, numbering only 3,540 roe shad and 3,060 bucks, valued locally at $1,320.

RARITAN BAY.

Raritan Bay occupies the triangular space between Staten Island, New York, and the coast of Middlesex and Monmouth counties, N. J., and its waters commingle with those of the ocean through Lower Bay. Its shad fisheries are valuable, the annual yield approximating 50,000, the forms of apparatus used being pound nets, stake nets, seines, and fyke nets. Of the 43,637 shad taken in 1896, 26,702 were obtained in pound nets, 15,675 in stake nets, 1,010 in seines, and 250 in fyke nets. The stake nets are set specially for shad, but the pound nets, seines, and fyke nets depend principally on the catch of other species.

The stake nets range from 20 to 40 yards in length, averaging about 25 yards, and the season extends from the first week of April to the 15th or 20th of May. The number of nets used in 1896 was 982, with an aggregate length of 24,304 yards and valuation of $4,256, requiring 73 men and 40 boats. Their catch of shad amounted to 8,515 roes and 7,160 bucks, valued locally at $3,409. The pound nets are set usually the first week of April, and shad are taken in them from that time until about the middle of May. They are owned by men living at Port Monmouth, Belford, and Keansburg, and the number of nets operated in 1896 was 35, valued at $26,750. Twenty-seven boats, worth $5,740, and 56 men were employed, and the catch of shad, which was very much less than usual, numbered 14,552 roes and 12,150 bucks, valued locally at $4,005. The 5 seines aggregated 3,733 yards in length and $2,450 in value, with 2½-inch mesh, and their catch of shad numbered 485 roes and 525 bucks, valued locally at $223. These seines are hauled principally for squeteague, striped bass, and alewives. The Port Monmouth fyke-net fishermen usually catch a small number of shad, the catch in the 25 fykes in 1896 numbering 140 roes and 110 bucks.

Raritan River.—The Raritan is the longest river situated wholly within New Jersey. Its sources are in the northwestern part of the State, the main stream being formed by the junction of the north and south branches, 4 or 5 miles west of Somerville, whence it flows a distance of 45 miles to its entrance into Raritan Bay at South Amboy. It is a tidal and navigable stream from the bay to the city of New Brunswick, a distance of 14 miles. The shad fisheries of Raritan River in 1896 consisted in the use of 11 fyke nets, worth $550, which were set near the mouth of the river from March 1 to June 10. They were operated by 1 man using 1 boat, worth $60, and the catch of shad approximated 2,500, which were sold locally at $938. These fykes are also set from September to December for striped bass.

In that section of the New Jersey shore bordering New York Bay and Hudson River many shad are caught each year, the yield in 1896 being 217,858, of which 49,758 were caught in fyke nets in New York Bay and 168,800 in stake nets in Hudson River. A description of the entire fisheries of these water areas is given in the chapter on the shad fisheries of New York State.

THE SHAD FISHERIES OF NEW YORK.

The shad fisheries of New York State are located principally in Hudson River and the sections of New York Bay leading thereto, over 98 per cent of the yield in 1896 being obtained in those waters. A few shad are also obtained in the Nissequague River, Little Neck Bay, Gardiner Bay, Long Island Sound, and Great South Bay, but the catch in the last three bodies of water is merely incidental to the taking of other species of fish.

The following series of tables shows the extent of the shad fisheries of each water area of this State:

Statement, by water areas, of the number of persons employed in each branch of the shad fisheries of New York in 1896.

Waters.	Number of fishermen.								Shoresmen.	Total
	Gill-net.			Seine.	Pound-net.	Fyke-net.	Spear.	Total, exclusive of duplication.		
	Drift.	Stake.	Pole.							
New York Bay:										
Lower Bay					18			18		18
Gravesend Bay					8	8		8		8
The Narrows	120							120		120
Upper Bay		21						21	1	22
Hudson River	583	64	2	250		6		901	9	910
Little Neck Bay	2				8			10		10
Nissequague River	24						20	28		28
Total	729	85	2	250	34	14	20	1,106	10	1,116

Statement, by water areas, of the number of boats, apparatus, etc., employed in the shad fisheries of New York in 1896.

Waters.	Boats.		Drift nets.			Stake nets.			Pole nets.		
	No.	Value.	No.	Length.	Value.	No.	Length.	Value.	No.	Length.	Value.
New York Bay:				*Yards.*			*Yards.*			*Yards.*	
Lower Bay	6	$530									
Gravesend Bay	6	600									
The Narrows	59	3,620	106	46,900	$6,560						
Upper Bay	10	2,000				302	2,416	$1,510			
Hudson River	447	18,774	337	164,020	23,425	1,099	8,438	2,268	2	445	$100
Long Island Sound:											
Nissequague River	12	240	12	408	124						
Little Neck Bay	7	401	1	760	80						
Total	547	26,165	456	212,088	30,189	1,401	10,854	3,778	2	445	100

Waters.	Seines.			Pound nets.		Fyke nets.		Spears.		Shore property.	Total value.
	No.	Length.	Value.	No.	Value.	No.	Value.	No.	Value.		
New York Bay:		*Yards.*									
Lower Bay				4	$1,000						$1,530
Gravesend Bay				2	1,200	34	$850			$300	2,950
The Narrows										350	10,530
Upper Bay										1,500	5,010
Hudson River	41	9,607	$5,840			20	105			4,880	55,392
Long Island Sound:											
Nissequague River								20	$20		384
Little Neck Bay				6	1,430					100	2,011
Total	41	9,607	5,840	12	3,630	54	955	20	20	7,130	77,807

Statement, by water areas, of the yield of shad in each form of apparatus employed in the fisheries of New York in 1896.

Waters.	Drift nets.		Stake nets.		Pole nets.		Seines.	
	No.	Value.	No.	Value.	No.	Value.	No.	Value.
New York Bay:								
The Narrows	63,500	$7,620						
Upper Bay			30,000	$3,600				
Hudson River	297,178	42,958	38,975	6,233	14,800	$616	68,345	$8,991
Long Island Sound:								
Nissequague River	1,256	314						
Little Neck Bay	128	46						
Total	362,062	50,938	68,975	9,833	14,800	616	68,345	8,991

Waters.	Pound nets.		Fyke nets.		Spears.		Total.	
	No.	Value.	No.	Value.	No.	Value.	No.	Value.
New York Bay:								
Lower Bay	14,000	$1,680					14,000	$1,680
Gravesend Bay	1,630	195	4,800	$576			6,430	771
The Narrows							63,500	7,620
Upper Bay							30,000	3,600
Hudson River			800	123			420,098	58,921
Great South Bay	*a* 364	61					364	61
Gardiner Bay	*a* 4,391	1,031					4,391	1,031
Long Island Sound	*a* 516	145					516	145
Nissequague River					482	$115	1,738	429
Little Neck Bay	1,649	529					1,777	575
Total	22,550	3,641	5,600	699	482	115	542,814	74,833

a Incidental catch.

NEW YORK BAY.

The numerous bodies of water leading from the ocean to the mouth of Hudson River have several designations, but the name New York Bay applies to the whole area from Sandy Hook to the Battery. The near approach of Staten Island to the western end of Long Island divides the bay into two unequal portions, known as Upper Bay and Lower Bay. The general form of Lower Bay is that of an equilateral triangle, each side of which approximates 15 miles in length. Upper Bay is about 5 miles long and 3 or 4 miles in width. Connecting the two, occupying the space between Long Island and Staten Island, are the Narrows, the least width of which approximates 1 mile. At the extreme upper end of Lower Bay, occupying the cove between Coney Island light and Fort Hamilton, is Gravesend Bay, a small body of water covering about 2 square miles. The fisheries of each of these water areas are described in succession.

Lower Bay.—The shad fisheries of Lower Bay are confined to the use of several pound nets on the shore of Staten Island between Elm Tree beacon and Fort Tompkins light. These nets are set separately in 12 to 15 feet of water, and are worth about $250 each. Four were used in 1896, requiring 18 men and 6 boats, the value of the latter being $930. The season began April 1 and ended about the middle of June, and the catch approximated 8,400 roes and 5,600 bucks, valued locally at $1,680.

Gravesend Bay.—The shad fisheries of Gravesend Bay in 1896 were represented by 2 large pound nets and 2 rows of fyke nets, set in from 10 to 25 feet, the pound nets being set individually and the fyke nets with 30 in one row and 4 in another. The pound nets are larger than those on the shore of Staten Island, and are valued at $600 each. It is necessary to have two sets of twine, since the large quantity of drift and refuse becoming fixed to them prevents their being operated more than a week at a time. Each of the fyke nets has five 14-foot hoops with two funnels to the net. The catch of shad by the 2 pound nets numbered 978 roes and 652 bucks, worth $195, while the fyke nets caught 2,880 roes and 1,920 bucks, valued at $576.

The Narrows.—Each season a large number of shad drift nets are operated in the Narrows, the season beginning usually about April 1, two or three weeks before the Hudson River season opens, and closes about May 15. The nets average 400 yards in length with 5⅛ to 5½ inch mesh, and cost about $75 each. On account of the extensive navigation through this channel it is necessary to operate the nets 25 or 30 feet below the surface, this being effected by long buoy lines, the most usual length being 26 feet. Even at this depth the suction of large steamers frequently entangles the nets in a mass and sometimes even lifts them up into the screws. In 1896 there were 59 boats drifting nets in the Narrows, using 46,900 yards of twine and operated by 120 men. The catch was much less than usual, the total number of shad taken being 38,100 roes and 25,400 bucks, valued locally at $7,620. Most of the fishermen live on Staten Island and at Bay Ridge, Fort Hamilton, and Gravesend on Long Island. The others live "up the river" and elsewhere and rendezvous at Fort Hamilton during the fishing season. The latter operate also to some extent on the Hudson, but the Narrows is their principal fishing-ground.

Upper Bay.—In the Upper Bay shad were taken by means of stake nets and fyke nets set along the western side of the bay on the Jersey Flats, between the northern end of Staten Island and Bedloe Island. The stake nets were owned by fishermen from Bay Ridge, and were set in 4 rows containing 151 "stations." The abundance of drift matter and other refuse in the water necessitated the use of two sets of nets, each remaining in the water about a week, thus requiring 302 nets for the 151 "stations." The nets were each 24 feet long by 28 feet deep, with 5¼-inch mesh, and were set with the top from 10 to 12 feet below the surface of the water. The poles were from 60 to 70 feet in length, and 26 feet apart in the rows. To operate these 4 strings of nets required the services of 21 fishermen, using 10 boats, valued at $2,000. The season began about the 1st of April and lasted six weeks, the total yield of shad approximating 30,000 in number, of which about three-fifths were roes. The fyke nets are owned by fishermen from Hudson County, N. J. The yield in the 214 used in 1896 numbered 27,267 roe shad and 22,491 bucks, for which the fishermen received $7,337.

HUDSON RIVER.

In point of commerce the Hudson is the most important river of the United States, and formerly its shad fisheries were the most valuable on the Atlantic seaboard, but in this particular it is now surpassed by several other rivers. Its sources are in the Adirondack Mountains in Essex County, whence it flows in a general southeasterly direction about 110 miles to Sandy Hill, and thence almost due south nearly 200 miles, to its entrance into New York Bay. From New York Bay to Piermont the width is from 1 to 2 miles; between Piermont and Haverstraw it expands into Tappan Bay, with a length of 12 miles and a width of 4 or 5 miles; while from Haverstraw, 34 miles distant from New York, to Albany the width of the river varies from 900 to 300 yards. At Troy, 6 miles above Albany, it receives its principal tributary, the Mohawk, whose volume of water is greater than that of the Hudson above that point. Above Troy the river partakes of the characteristics of a large mountain stream, with numerous falls and rapids.

At Troy there is a State dam, built in 1826, of log cribwork filled in with stone, 1,100 feet long and 10 feet high, which forms an impassable barrier to the further progress of shad except when the water rises above the crest of the dam during high freshets. There was formerly a fishway in this obstruction, but it was destroyed by a freshet several years ago and has not been replaced. At Mechanicsville, 9 miles above Troy, there is a dam of cut-stone masonry 16 feet high, built in 1882. Three-quarters of a mile above is a dilapidated log dam with an original height of 8 feet. At Stillwater, 3 miles above Mechanicsville, there is another log dam, forming an irregular line 6 feet high across the stream. Above Stillwater the river is comparatively level for a distance of 12 or 13 miles, almost to the Saratoga dam, which is of stone, 8 feet in height, built in 1873. Above Saratoga there are several other dams from 2 to 16 feet in height, among which are those at Fort Miller, Fort Edward, Sandy Hill, Glens Falls, Palmer Falls, etc. Prior to the construction of the Troy dam, in 1826, shad ascended the Hudson to the falls at Sandy Hill, 50 miles above Troy, and up to fifteen years ago they were taken in some abundance within a short distance below Troy. But during recent years there has been little fishing above Castleton, a short distance below Albany.

Shad enter the Hudson usually during the first week in April and remain until the last of June. The legal season extends from March 14 to June 15 of each year, with a close time operative from sunset on Saturday until sunrise on Monday of each week. The fisheries extend from the mouth of the river nearly to Albany, the river being well filled with twine up to Hudson, in Columbia County, while above that town few fish are taken. The yield fluctuates considerably from year to year. In 1880 there were 711 men employed and the catch of shad numbered 639,000. In 1885 the yield was reported at 1,174,835,

in 1886 at 1,300,949, and in 1887 at 1,568,634. In 1895 the yield was 1,155,610, but in 1896 only 588,898 shad were taken in this river, the local value of which was $83,237. Of this yield, 297,178 were caught in drift nets, 180,775 in stake nets, 68,345 in seines, 41,800 in pole nets, and 800 in fykes. The catch by the New Jersey fishermen numbered 168,800, while 420,098 were taken therein by residents of New York State.

The following table shows by States the number of persons employed in each branch of the shad fisheries of the Hudson River in 1896:

Fishery.	New Jersey.	New York.	Total.
Drift-net		583	583
Stake-net	176	64	240
Pole-net	8	2	10
Seine		250	250
Fyke-net		6	6
Shoresmen		9	9
Total exclusive of duplication	176	910	1,086

The following table shows by States the apparatus employed in each branch of the shad fisheries of the Hudson River in 1896:

Apparatus, etc.	New Jersey.		New York.		Total.	
	Number.	Value.	Number.	Value.	Number.	Value.
Boats	69	$4,905	447	$18,774	516	$23,679
Drift nets			337	23,425	337	23,425
Stake nets	1,518	7,425	1,099	2,268	2,617	9,693
Pole nets	12	510	2	100	14	610
Seines			41	5,840	41	5,840
Fyke nets			20	105	20	105
Shore property		1,175		4,880		6,055
Total		14,015		55,392		69,407

The following table shows by States the number of shad caught in each form of apparatus in the Hudson River in 1896:

Apparatus.	New Jersey.		New York.		Total.	
	Number.	Value.	Number.	Value.	Number.	Value.
Drift nets			297,178	$42,958	297,178	$42,958
Stake nets	141,800	$20,590	38,975	6,233	180,775	26,823
Pole nets	27,000	3,726	14,800	616	41,800	4,342
Seines			68,345	8,991	68,345	8,991
Fyke nets			800	123	800	123
Total	168,800	24,316	420,098	58,921	588,898	83,237

Drift nets are used on the Hudson from the New Jersey line to within a short distance of the Troy dam. In the lower half of the river, below Saugerties in Ulster County, the nets range from 450 to 1,000 yards in length, with an average of about 500 yards, but the length, as well as the depth, depends on the size of the channel in which they are operated, the nets being as large as the width of the channel admits. The largest nets are used at Hyde Park, Highland, West Point, and Verplanck Point, the last named being the center of the

most extensive fishery on the river. To avoid injury from vessels, the buoy lines are so arranged as to permit the net to drift 6 to 30 feet below the surface. The drift nets reported from this river in 1896 numbered 337, with an aggregate length of 206,590 yards and value of $23,425, while the catch aggregated 162,385 roe shad and 134,793 bucks, valued locally at $42,958.

The upper limit of the stake-net fishery is Croton Point, on the east side of the river, just above Sing Sing, while on the west side the uppermost limit is Nyack, Rockland County. The stake nets north of the Jersey line are small and inexpensive, costing about $1.50 each, being set on the flats in shallow water, not over 15 feet deep. The catch by the shoal-water nets in 1896 was unusually small, as the shad kept well out in the channel. In 1895 the fish ran more inshore, so that those nets made good catches. The stake nets between Alpine, N. J., and the mouth of the river are much larger and are set on the edge of the channel, in water 20 to 50 feet deep. The usual dimensions of these nets are 90 meshes long and 100 meshes deep, with 5 inch mesh; many, however, are 100 meshes square. The depth necessitates poles of great length and strength, hickory and white oak being used generally. The nets are set in rows of 25 or 30 each, running from the shore to the middle of the channel. On the New York side there were no stake nets below Fort Washington Point, and between there and Yonkers there were but 3 rows, containing 120 nets; but on the New Jersey side, between the mouth of the river and Alpine, opposite Yonkers, N.Y., there were 1,518 stake nets in 1896, which caught 141,800 shad—more than one-fourth the yield of the entire river.

The stake nets in the extreme lower end of the river are subject to considerable damage from the vessels continually passing, the greatest amount of injury being done at night, when it is not always possible to avoid the twine. Not infrequently a fisherman will have one-third of his nets destroyed in a single night, and a large percentage of loss in this manner is always expected. However, the fishermen claim that much of the damage is the result of pure indifference on the part of vessel captains, who make no effort to avoid the twine. The total number of stake nets on the river in 1896 was 2,617, aggregating 21,170 yards in length, and valued at $9,693, and their catch numbered 106,065 roe shad and 74,710 bucks, worth $26,823. Of this yield 85,080 roes and 56,720 bucks were taken in the 1,518 nets set on the New Jersey shore, and 20,985 roes and 17,990 bucks in the 1,099 nets set in the New York portion of the river.

A third form of gill net used on the Hudson River, known as the "pole net," is similar in construction to the drift net, but its mode of operation is somewhat like that of a stake net. The net is a continuous section, 200 to 250 yards in length, costing from $40 to $60. Poles are set on the edge of the channel about 35 feet apart, and to the lower side of which the net is fastened at the commencement of every flood tide by means of "arms" or ropes 6 feet long. At the end of the flood tide the

net is lifted, the fish removed, and the net is again set at the beginning of the succeeding flood tide. There were but 14 of these nets on the river in 1896, but they were quite successful, the average catch being about 3,000 shad, and another season will doubtless witness an extended use of this form of apparatus.

Compared with those of the Delaware River, the seine fisheries of the Hudson are of little importance, a single seine on the former stream taking more shad each year than the 40 or more on the Hudson. The seines range in length from 120 to 500 yards, with from 2 to 2½ inch mesh in the bunt and 4-inch to 5-inch mesh in the wings. The seven operated in the lower 80 miles of the river take few shad, their catch consisting principally of alewives and other species. The most extensive seine fishery on the river is near Kinston Point, where two seines are operated by steam launches from a scow anchored in the middle of the river, the catch by which in 1896 numbered 7,200 roe shad and 4,800 bucks—nearly one-fifth of the entire seine catch on the river. The total shad yield of the 41 seines operated in 1896 was 41,757 roes and 26,588 bucks, valued locally at $8,991.

GREAT SOUTH BAY AND GARDINER BAY.

A few shad are caught incidentally in the pound nets set in Great South Bay, the yield in 31 pound nets set in the spring of 1896 being reported at 196 roes and 168 bucks. This small catch was due to the lateness of the period when the nets were set.

In the pound nets at the eastern end of Long Island Sound, between Montauk Point and Orient Point, some shad are taken each year. The nets are most numerous in Fort Pond Bay and Napeague Bay and along the shores of Gardiner Island. Shad are caught during April and May and are obtained in greatest number on the eastern side of Gardiner Island. The total number of nets in 1896 was 105, and their catch of shad numbered 1,600 roes and 2,791 bucks, for which the fishermen received $1,031.

LONG ISLAND SOUND.

Most of the shad entering Long Island Sound pass along the northern shore of that body of water and enter the large tributaries flowing into it through the State of Connecticut, very few being taken on the New York shore. Of the 74,319 shad caught in this sound and tributaries in 1896, 70,288 were taken along the northern shore and in the rivers flowing therein, while only 4,031 were taken along the southern shore. Of the latter, 516 were taken in pound nets near Orient Point, 1,738 in Nissequague River, and 1,777 in Little Neck Bay. Shad doubtless run into the other small bays and tributaries along this shore, but in numbers too small to warrant the establishment of fisheries. The shad fisheries of the three sections above noted will be described separately, while those of the waters tributary to the northern side of Long

Island Sound will be described in the chapter on the shad fisheries of Connecticut.

In the pound nets at the eastern end of the sound on the Suffolk County shore, between Orient Point and Horton Point, a few shad are taken incidentally with other species. These nets run out from the shore into 20 or 30 feet of water, one net being the usual number to the string. In 1896 there were 14 pound nets in this locality, and the catch of shad numbered 210 roes and 306 bucks, valued at $145.

Nissequague River.—Westward of Horton Point no shad are taken on the southern shore of Long Island Sound until Nissequague River is reached. This is a small sand-hill stream extending from Smithtown Bay for several miles into the interior. While shad have been caught in this stream for a number of years, yet fisheries have been prosecuted only during the past two or three years. The fisheries were most extensive in 1896, when drift nets were operated at various times, catching 1,256 shad from May 1 to May 13. On the night of May 13 fishing was stopped by the local authorities, the twine being destroyed and arrests made of a number of the fishermen. After that date many of the fishermen engaged in taking shad by the means of spears, it being easier to elude arrest when so engaged than when using a drift net.

The number caught by spears from May 13 to the end of the season, about June 12, approximated 482, over half of which were roes. This made a total of 1,738 shad taken in the Nissequague in 1896. If the operations of the fishermen had not been interfered with the yield for the season might possibly have approached 5,000.

Little Neck Bay.—This bay is quite shallow and covers only 2 or 3 square miles. Strictly speaking, it is not a tributary of Long Island Sound, but rather of East River, and it is claimed that the shad enter this body of water by way of East River and the Narrows and not through Long Island Sound. Seasons of scarcity in Little Neck Bay are usually coincident with those in New York Bay and Hudson River, and not with those in the Connecticut. Shad have been taken in Little Neck Bay each season for many years, the principal apparatus employed being pound nets, which are set from April 15 to about June 10. In 1896 there were 6 nets used, worth $1,430, but the yield of shad was unusually small, numbering only 776 roes and 873 bucks, for which the fishermen received $529. One pound net, which in 1896 caught only 29 shad, yielded 1,154 in 1895, and prior to 1890 the average annual catch was about 2,000 for each net. A single gill net was used in this bay in 1896. This net was 760 yards in length, and the catch numbered 92 roe shad and 36 bucks, valued at $46, making a total of 1,777 shad, worth $575, taken in this body of water.

THE SHAD FISHERIES OF CONNECTICUT.

The extent, by water areas, of each branch of the shad fisheries of Connecticut is presented in the following series of tables:

Statement, by water areas, of the number of persons employed in each branch of the shad fisheries of Connecticut in 1896.

Waters.	Drift-net.	Seine.	Total, exclusive of duplication.
Long Island Sound: *a*			
Connecticut River	94	36	130
Housatonic River	34	17	45
Bridgeport Harbor	6		6
Pine Creek	4		4
Total	138	53	185

a In Long Island Sound a number of men operate pound nets, in which shad are taken incidentally, but there are no regular shad fisheries on the Connecticut shore of that sound.

Statement, by water areas, of the boats, apparatus, etc., employed in the shad fisheries of Connecticut in 1896.

Waters.	Boats.		Drift nets.			Seines.			Shore property.	Total investment.
	No.	Value.	No.	Length.	Value.	No.	Length.	Value.		
Long Island Sound:				*Yards.*			*Yards.*			
Connecticut River	59	$1,200	48	13,858	$3,321	12	1,883	$863	$465	$5,849
Housatonic River	34	966	29	5,640	820	5	1,165	380	370	2,536
Bridgeport Harbor	5	80	5	540	78				100	258
Pine Creek	4	60	4	155	46				20	126
Total	102	2,306	86	20,193	4,265	17	3,048	1,243	955	8,769

Statement, by water areas, of the yield of shad in each form of apparatus employed in the fisheries of Connecticut in 1896.

Waters.	Drift nets.		Seines.		Pound nets.		Total.	
	No.	Value.	No.	Value.	No.	Value.	No.	Value.
Long Island Sound			*a* 41	$10	*a* 7,093	$1,669	7,134	$1,679
Connecticut River	45,851	$8,244	*b* 5,839	1,264			51,690	9,508
Housatonic River	8,286	2,072	1,592	399			9,878	2,471
Bridgeport Harbor	1,017	285					1,017	285
Pine Creek	569	139					569	139
Total	55,723	10,740	7,472	1,673	7,093	1,669	70,288	14,082

a Caught incidentally in apparatus set especially for other fish than shad.
b Of these, 146 shad, worth $30, were taken in seines operated especially for alewives.

LONG ISLAND SOUND.

This sound, occupying the coastal depression between Long Island and the shore of Connecticut, approximates 115 miles in length and 15 to 25 miles in width. It is comparatively shallow, the depth in the eastern portion being usually less than 200 feet, while in the part west of Connecticut River it averages from 75 to 100 feet. At its eastern end there is a chain of islands extending in a northeasterly direction from Long Island to Rhode Island, and through the passages between these islands the waters of the sound mingle with those of the ocean,

the principal channel being the Race, between Little Gull Island and Fisher Island. At its western end the sound connects with the waters of New York Bay through a long narrow passage known as East River, which separates the western end of Long Island from New York City. Throughout its length, except near the mouth of the large rivers, the density of the water is very little less than that of the ocean. The principal river tributaries are the Thames, Connecticut, and Housatonic, which bring down large quantities of fresh water.

While some shad doubtless enter Long Island Sound through East River, the great bulk passes through the Race at the eastern end. They appear usually about the second week of April and are taken first in the pound nets set immediately west of the mouth of Connecticut River. Most of them pass up the Connecticut, but a large number proceed westward, a few being caught in the pound nets set along the shore, while others enter the Housatonic and some of the smaller streams of Connecticut and Long Island. The run into these waters during recent years appears to be much smaller than formerly. The catch in 1896 in the sound and its tributaries numbered only 74,321, of which 51,690 were taken in the Connecticut, 9,878 in the Housatonic, and the remaining 12,753 along the shore of the sound and in smaller tributaries, whereas the catch in the Connecticut alone was formerly half a million or more.

While a few shad are caught in Long Island Sound proper, there are no fisheries dependent exclusively on that species. At the southeastern end, on the shore of Long Island between Orient Point and Horton Point, there are a few pound nets each year which take some shad, the number of nets in 1896 being 14, and the yield of shad numbering 516. Very few shad run along the northern shore of Long Island Sound east of Connecticut River, and in the 77 pound nets there in 1896 only 244 shad were caught. In 28 of those nets not a single shad was taken, and 20 was the highest number caught in any net. In 1895 the 182 pound nets on that shore yielded 290 shad.

Between Connecticut River and New Haven Harbor shad are somewhat more numerous, and a number are taken in the pound nets. Immediately at the mouth of the Connecticut, between the jetties and Cornfield Point, there were 3 pound nets in 1896, which yielded more shad than all the rest of the nets in the sound. They were set about the 10th of April, and from that time to the middle of June the three caught 4,592 shad, worth $1,083, of which 2,327 were roes and 2,265 were bucks. Seven or eight miles west of the above three nets, between Duck Island and Kelsey Point, there were three other pound nets, which yielded 197 roe shad and 295 bucks. A 100-yard seine, operated at the mouth of the Hammonasset River in 1896, caught 16 roe and 25 buck shad among other species. The area occupied by the 6 pound nets above mentioned was formerly the location of one of the most profitable shad fisheries on the coast. As late as 1885 there were 49 pound nets in that section, which yielded 123,100 shad. In 1886 there

were 48 nets and the catch numbered 69,900, while in 1887 the number of nets was 46 and the yield of shad 61,950. Pound nets were set in this section for the first time in 1849. The largest catches were made from 1863 to 1871 and from 1875 to 1880. During 1872, 1873, and 1874 adverse legislation restricted the use of these nets to three days in the week.

The following summary shows the number of shad taken annually during a series of years in a single pound net located at Money Point, about 6 miles west of the mouth of the Connecticut River, the location being the same each year:

Year.	No. of shad.	Year.	No. of shad.	Year.	No. of shad.	Year.	No. of shad.
1856	3,643	1864	12,265	1872	*a* 8,271	1880	13,275
1857	5,183	1865	9,410	1873	*a* 7,343	1881	10,500
1858	6,111	1866	10,594	1874	*a* 9,290	1882	9,637
1859	3,000	1867	12,500	1875	20,037	1883	6,200
1860	6,000	1868	13,000	1876	11,041	1884	7,200
1861	6,100	1869	11,000	1877	10,465	1885	7,858
1862	6,853	1870	16,558	1878	*b* 4,550		
1863	10,730	1871	13,508	1879	19,175		

a Law restricted fishing to three days in each week. *b* Net very much injured by jelly-fish.

Between Hammonasset Point and New Haven Harbor there were 15 pound nets set in the spring of 1896 for menhaden and other species, which yielded 724 roe shad and 864 bucks. Of these, 206 roes and 285 bucks were taken in one net near the mouth of Farm River, whereas in 1895 943 shad were taken in 3 nets set in the same locality. In 1886 there were 27 nets between Hammonasset Point and New Haven harbor, which yielded 10,300 shad, while in 1885 30 nets in the same locality caught 18,200. In 1887 there were 38 nets in the locality named, and the yield of shad was 9,300. The only apparatus which was operated on the Connecticut shore west of New Haven Harbor in which shad are reported to have been caught, was 1 pound net at Welch Point, near the town of Milford, which yielded 177 shad in 1896 and 189 in 1895.

THAMES RIVER.

This river is really an estuary of Long Island Sound, extending 15 miles northward to Norwich, where it receives the waters of the Shetucket and Yantic rivers. Its width varies from a quarter to half a mile, except that near the mouth it is a mile or more wide, forming the excellent harbor of New London. On both the Shetucket and Yantic rivers there are numerous dams extending to within a short distance of their entrance into the Thames, forming complete barriers to the ascent of fish. Previous to 1880 a considerable number of shad were caught in Thames River, the yield during the height of the season being several hundred daily, but during the past ten or fifteen years very few have been taken. In 1885, 300 were reported; in 1886, 45; in 1887, 27; and in 1888 only 4 were caught, while in 1889 and 1890 there were none reported; in 1891, 2 were taken, and in 1893 there was 1, and since that year no shad have been reported from this river.

CONNECTICUT RIVER.

With the exception of Kennebec River, the Connecticut is the principal shad stream of New England. This river rises in the extreme northern part of New Hampshire, within half a mile of the Canadian border, flows in a general southerly direction a distance of 375 miles, forming the boundary line between New Hampshire and Vermont, and, traversing Massachusetts and Connecticut, empties into Long Island Sound near the eastern end. It is navigable for steamers from the mouth to Hartford, a distance of 50 miles. Above Hartford there are numerous falls, the most important being Enfield, Holyoke, Turner, Bellows, Olcott, and McInloe, all of which are provided with dams for developing water-power.

At Enfield, 66 miles from the sound, the river descends over a rocky bed, with a fall of 32 feet in a distance of 5 miles. A dam 1,500 feet long and 4 feet high, built of logs filled in with stone, extends in a broken line across the river. Originally this dam consisted of two wings running out from either side of the river, leaving an opening of 150 feet for navigation purposes. This opening was closed about fifteen years ago by a new section of dam 5 feet high, in the middle of which there is a fishway 40 feet long. Windsor Locks Canal permits the passage of small boats around the obstruction. The Enfield dam has caused much irritation among the fishermen above that point, especially among those in Massachusetts. In 1886 the general assembly of that State adopted a resolution suggesting mutual measures on the part of the States of Connecticut and Massachusetts toward overcoming this obstruction, but no satisfactory result was accomplished.

The Holyoke dam, 18 miles above Enfield, extends entirely across the river, with a length of over 1,000 feet and a height of 35 feet. It was completed in 1849 and is one of the most substantial constructions of its kind in the country, developing about 15,000 horse-power, used mainly in the manufacture of paper. During freshets the water on the crest of the dam is sometimes several feet deep, but ordinarily there is little overflow. A condition was imposed in the charter that the Holyoke Water Power Company should pay for the fisheries destroyed above the dam, and this requirement was complied with. Under a provision of the common law enjoining owners of dams high enough to stop the passage of fish to provide a suitable fishway, the Holyoke company was directed to build a fishway. The company contended that it was exempt from this common-law injunction because it already had paid for the fisheries destroyed above the dam, as required by the charter.

In a very interesting case, involving the rights of river fisheries, of the water-power corporations, and of the eminent domain of the State over both, the United States Supreme Court, affirming the decisions of the supreme court of Massachusetts, decided that as the dam had injured the fisheries below as well as destroying those above that

obstruction, it was subject to the common-law provision and must build a fishway. The fishway was completed in 1873, it being after the Brackett plan, a modification of the Foster fishway. It is one of the largest and most expensive ever constructed, being 440 feet in length, with a general inclination of 1 foot in 15, divided into compartments or bays by means of ⊥-shaped partitions that extend at right angles from the sides, causing the water to wind through such a long, circuitous course that it actually runs about 1,500 feet before it emerges at the lower end. As the height of the dam is 30 feet, the fall of the water averages about 1 foot in 50 with little momentum, but it does not appear that shad have ever passed above this fishway in quantities.

During the colonial period shad were abundant in the lower half of Connecticut River, ascending as far as Bellows Falls, 170 miles from Long Island Sound, where the abrupt descent of the river prevented further progress. They easily passed Turner Falls, 50 miles below, several thousand being taken there in a single day with dip nets. The first artificial obstruction to their progress was the dam at Turner Falls, erected in 1798. This obstruction prevented shad from passing that point, and it also seriously affected the spawning of salmon in the river, but, as there were areas below Turner Falls suitable for shad spawning, the run of this species below that point was not apparently injured.

In 1849 the dam at Holyoke was completed, cutting off 36 miles more from the upper limit of the shad run, including many spawning-grounds. The effect of this is shown distinctly in the reliable accounts of the catch made at the Parsonage seine fishery, near the mouth of the river. The average annual yield of shad from 1827 to 1836 was 10,376; during the succeeding ten years it was 9,332, the slight decline being perhaps attributable to increased fishing at near-by points. The erection of the Holyoke dam in 1849 prevented the fish from ascending to the upper waters, and as they retreated down the river they were taken more abundantly than formerly. The average yearly catch by the Parsonage seine in the five years following the erection of the dam was 19,490 shad; during the next ten years (1854–1863) the average was but 8,364, and for the following six years (1864–1869) it further decreased to 4,482 annually, less than one-half of the former yield.

For many years preceding 1881 the regulations of Massachusetts and Connecticut in reference to the Connecticut River shad fisheries were similar, a close season beginning June 21, and an interdiction prevailing against the use of nets with less than 5-inch mesh. An increased use of pound nets at the mouth of the river aroused much antagonism among the up-river fishermen, especially those in Massachusetts, and resulted in the spring of 1881 in an enactment by the legislature of that State extending the open season to July 1 and permitting the use of nets with 2-inch mesh. The effect of this enactment is well shown in the table on page 256. In 1880, by the use of 5 inch mesh, only 7,727 shad were taken in that portion of the Connecticut situated in Massa-

chusetts, while the small mesh in the following season caught 38,382 shad, nearly five times as many as during the previous year, the small mesh permitting the capture of shad of all sizes. This resulted in a greatly diminished catch during succeeding years. In 1882 the number of shad taken in that portion of the river was but 2,770, or less than 8 per cent of the yield in the year previous, and the largest product in any one season since has been but 3,591, or less than 10 per cent of the yield in 1881. Since 1883 the product decreased annually, and it does not appear that any shad have been taken in that portion of the Connecticut since 1890. The average yield for the six years ending in 1881 was 16,100 annually, and during the fifteen years following 1881 it has been only 852 shad annually.

At present the Connecticut River shad fisheries extend from Long Island Sound to Wethersfield, a distance of 40 miles, but they are most extensive in the reaches between Essex and Haddam. The yield in 1896 aggregated 45,851 taken in drift nets and 5,839 in seines. The fishery by drift nets is most extensive from Essex to Higganum, the principal centers being Hamburg, Chester, Hadlyme, Higganum, and Haddam.

The number of nets used in the river in 1896 was 48, of which 31 were operated by men living in Middlesex County, 15 by men from New London County, and 2 by Hartford County fishermen. These measure in length from 140 to 350 yards, averaging about 290 yards, with 5½-inch mesh, and cost about $70 each, each net requiring one boat, worth $20, and 2 men.

The season is dependent on the movements of ice in the river, but it generally begins the first or second week in April and extends to the third week of June. The legal season extends from March 1 to June 20 of each year, and fishing is interdicted from sunset on Saturday night to sunset on the following Sunday night of each week.

Of the total yield in 1896, 22,197 were roes and 23,654 bucks, the price received for the former being $5,200 and for the latter $3,044. Seines were formerly the only apparatus used for taking shad in the Connecticut, but these have been gradually superseded by drift nets. In 1896 there were only 12 seines used, most of which were operated between Haddam and Wethersfield. These approximated 150 yards in length, and several were used mainly for catching alewives. Their yield of shad was the largest since 1880, numbering 5,839, valued at $1,261. A seine at Wethersfield caught 2,799 shad in 1896, against 730 in 1895. Another seine at the same place caught 1,894 shad in 1896 and but 709 in 1895.

The following compilation shows the number of shad taken in Connecticut River during a number of years. Returns for years previous to 1879 for that portion of the river situated in Connecticut are not available. The South Hadley seine fishery, a short distance below the Holyoke dam, was formerly the most valuable seine fishery above the Enfield dam. The yield at that fishery is also noted in the table.

Table showing the number of shad taken in Connecticut River during a number of years, also the yield at the South Hadley seine fishery.

Year.	Connecticut.	Massachusetts.	Total.	Yield at South Hadley fishery.	Year.	Connecticut.	Massachusetts.	Total.	Yield at South Hadley fishery.
1853	....	....	....	45,000	1883	177,308	3,591	180,899	3,099
1865	....	....	....	35,000	1884	150,045	1,593	151,638	1,593
1868	....	....	....	7,341	1885	190,300	1,718	192,018	1,718
1869	....	....	....	8,807	1886	117,950	577	118,527	577
1870	....	....	....	779	1887	80,350	850	81,200	850
1872	....	....	....	4,822	1888	68,450	824	69,274	824
1873	....	....	....	3,598	1889	42,325	796	43,121	796
1874	....	....	....	3,016	1890	34,318	58	34,376	58
1876	....	12,792	....	10,741	1891	20,503	....	20,503	....
1877	....	6,503	....	3,412	1892	18,376	....	18,376	....
1878	....	17,790	....	8,169	1893	21,778	....	21,778	....
1879	436,981	13,409	450,390	6,296	1894	38,776	....	38,776	....
1880	269,918	7,727	277,645	4,698	1895	34,323	....	34,323	....
1881	351,678	38,382	390,060	18,196	1896	51,690	....	51,690	....
1882	272,903	2,770	275,673	2,114					

From the preceding statement it appears that during the six years following 1878 the shad yield aggregated 1,726,305; during the succeeding six years it was 538,516, and during the six years ending in 1896 only 185,447 shad were taken in the Connecticut. The alleged reasons for the continued decrease are summed up as follows: (1) The erection of jetties at the mouth of the river, resulting in a change of the current flowing therefrom through Long Island Sound; (2) pollution of water by sewage and refuse from manufactories along the shore; (3) overfishing, and (4) the erection of dams across the stream, thereby preventing the fish from ascending to the spawning-beds. It is questionable whether the first-named factor has had any effect on the abundance of shad. The jetties deflect the current only slightly from its natural course, and should the shad not run up the Connecticut they would doubtless appear in increased numbers at other points in Long Island Sound, which does not seem to have been the case.

The second factor has undoubtedly had a very deleterious effect on the fisheries. That the sanitary conditions of the Connecticut are unfavorable to the existence of shad admits of no doubt, the sewage from the cities and the acid refuse from the numerous factories on the shores of the stream so polluting the water as to make it unfavorable to the existence of animal life therein. Especially is this the case during the summer months, when the young fish are in the river, the water becoming so tainted with acids and refuse that the surface is frequently spotted with dead fish. While the extensive fisheries have doubtless materially assisted in bringing about the present depleted condition of the Connecticut, yet they have merely hastened the work that would eventually be accomplished by the dams and the unsanitary state of the water, even if no fisheries existed. The most objectionable development of recent years is the concentration of the fisheries near the mouth of the river, nearly all the fish being caught before they have reached the spawning-grounds, thus reducing natural reproduction to almost an insignificant factor in keeping up the supply. It is apparent that the future of the Connecticut River shad fisheries is far more dependent on artificial propagation than has been the case in the past. But there is

little to be said favorable to further work of this nature unless improvement be made in the conditions of the river. Were this accomplished, artificial propagation could doubtless greatly increase the run of fish; and if suitable restrictions were applied to the fisheries the shad reaching the spawning-beds between Haddam and Windsor Locks might also tend to keep up the supply.

Farmington River.—The Farmington is the only one of the several tributaries of the Connecticut that has yielded shad during recent years. It rises in Berkshire County, Massachusetts, and, flowing a distance of 75 miles, enters the Connecticut about 5 miles above Hartford. At Poquonock, 5 miles above the mouth, there is a log dam 4 or 5 feet high and 261 feet long, entirely crossing the river. Above this point there are numerous other dams at short distances, forming a complete barrier to the ascent of fish. Formerly the shad fisheries of Farmington River were of some local importance, but during the past ten or twelve years the catch has been small. In 1881 the yield numbered 11,505, in 1882 it was 3,800, and in 1883 but 1,155 shad were caught. Since then the yield has been very small, except in 1885, when 3,400 shad were caught by seines. In 1896 one seine was used to obtain spawn for the State hatchery, catching about 500 shad, which represents the full extent of the fisheries during that year.

HOUSATONIC RIVER.

This river rises near Pittsfield in the western portion of Massachusetts, and, after flowing a distance of 123 miles, enters Long Island Sound 4 miles east of Bridgeport. It is navigable for 13 miles to Derby, where it receives its principal tributary, Naugatuck River, a small rapid stream. A mile or so above Derby the Housatonic is crossed by a stone dam 22 feet high and 636 feet in length, completed in 1870 at a cost of $430,000, and developing 1,500 horsepower, used for various manufacturing purposes. The usual spring-freshet depth over the crest is 4 or 5 feet. A fishway was built in this obstruction, the designs being furnished by the late Mr. Foster, of Maine. Very soon thereafter it appeared that shad would not pass above this dam, not even attempting to enter the fishway, although many were seen in immediate proximity to the lower end. The fishway was destroyed by freshets in 1873 and has not been rebuilt. Above Birmingham the fall of the Housatonic is very great, averaging 8 feet per mile. There are a few dams, the most important one of which is at Lanesville, where the fall obtained is 12 feet. Very few shad pass above the Birmingham dam, and none appear to go beyond Lanesville, 40 miles above the mouth. In the early part of the present century, previous to the erection of obstructions on the river, shad ascended to Falls Village, 73 miles from Long Island Sound. At that point the river falls abruptly over limestone ledges a total distance of 100 feet, forming a complete barrier to the further ascent of fish.

It was reported in 1883 that 11 seines on the Housatonic caught

11,550 shad and 27 gill nets caught 4,500, a total of 16,050, and in 1884 that the yield in 12 seines was 39,000 and in 47 gill nets 13,000, making a total of 52,000 shad taken on the Housatonic during that year. In 1885 the yield was 50,600; in 1886 it was reduced to 24,800, and in 1887 the catch of shad was still further reduced to 12,400. The present fisheries are confined to the use of a few drift nets and seines between the mouth of the river and Birmingham, the annual yield ranging from 8,000 to 15,000 in number. The drift nets in 1896 numbered 29, with a total length of 5,640 yards, requiring 29 boats, worth $536, and 34 men. Of these nets, 22 were used by men living on the east side of the river and 7 on the west side. The season began about the middle of April and extended to the third week of June. The catch was not up to the usual quantity, 8,286 shad being taken, of which 4,335 were roes and 3,951 bucks. In 1896 there were 5 seines operated below Birmingham by men living on the Fairfield County side of the river. These range in length from 150 to 250 yards, with from 3 to 5 inch mesh, and require three or four men and one boat for each. The seining season began about a week earlier and closed three weeks earlier than the drift-net season. The catch of shad was 812 roes and 780 bucks, making a total of 9,878 shad, worth $2,471, taken on the Housatonic River.

Bridgeport Harbor, Pine Creek, etc.—In the harbor of Bridgeport, 3 miles west of Housatonic River, a few shad are taken each year, most of them being secured in a channel known locally as "The Gut." In 1896 6 men operated 5 drift nets in that locality, and took 652 roe shad and 365 bucks, valued locally at $285. In Pine Creek, Black Rock Harbor, Ash Creek, and several other small streams between Bridgeport and Stamford, there are a few shad taken every season by means of short drift nets. Four shad fishermen, with an equal number of boats, are reported from those waters in 1896, using 4 drift nets, the catch in the season extending from April 20 to June 10, numbering 342 roe shad and 227 bucks, worth $139.

THE SHAD FISHERIES OF RHODE ISLAND.

The shad caught in Rhode Island are taken incidentally in apparatus set especially for other species, except that in Warren River 6 men used 3 pound nets, worth $920, 3 boats, worth $90, and shore property valued at $120, catching 9,258 shad. The following table shows by water areas the yield of shad in this State in 1896:

Statement showing, by water areas, the yield of shad in Rhode Island in 1896.

Waters.	Pound nets.		Miscellaneous.		Total.	
	No.	Value.	No.	Value.	No.	Value.
Atlantic Ocean	1,051	$287			1,051	$287
Narragansett Bay	2,163	589			2,163	589
Warren River	9,258	2,408			9,258	2,408
Pawcatuck River			400	$115	400	115
Providence-Blackstone River			500	142	500	142
Greenwich River			160	49	160	49
Total	12,472	3,284	1,060	306	13,532	3,590

OCEAN SHORE OF RHODE ISLAND.

Along the ocean shore of Rhode Island, from Watch Hill to Point Judith, there are several pound nets each spring in which a few shad are taken incidentally. These nets are set about April 20 and remain until the fall, catching shad during the first two or three weeks in which they are set, viz, from April 20 to May 10. There were 14 pound nets in this locality in 1896, the total value of which was $16,800, and their catch of shad is reported at 946, of which about 40 per cent were roes. The average weight of the roe shad approximated 5 pounds, while the bucks averaged in weight about 3 pounds each. The roes sold at an average price of 38 cents and the bucks at about 20 cents each. On the shore of Block Island there were 4 pound nets in 1896, valued at $4,900, in which 105 shad, worth $32, were taken. In 1895 the same 4 pound nets caught about 200 shad.

NARRAGANSETT BAY.

There are numerous pound nets set each spring at various points in Narragansett Bay, the principal species taken being scup, squeteague, and sea bass. The nets are most numerous off the southern shore of Newport Island, in Western Channel and between Sakonnet and Tiverton. In these pound nets a few shad are taken each year, but this species is rarely sufficiently numerous to receive special attention from the fishermen. In the 98 nets in Narragansett Bay in 1896, the catch of shad was 1,090 roes and 1,073 bucks. Over half of these were taken in 39 nets set in the Eastern Channel, between Sakonnet Point and Mount Hope Bay, the catch being 685 roes and 563 bucks. The largest yield in any single pound net was 70 roe shad and 78 bucks, obtained in a net off Rumstick Neck, at the northern end of Narragansett Bay near the mouth of Providence River.

Warren River.—While a few shad run up most of the tributaries of Narragansett Bay, yet they are not in sufficient numbers to support important fisheries, and the only well-known shad stream in the State is Warren River. This small stream is a tidal arm of Narragansett Bay near its northern limit. It is only a few hundred feet in width, about 10 miles in length, and contains no obstructions to the free passage of fish. It has been an important shad stream during the last thirty years at least. In 1880 it was reported that about 5,000 shad, with an average weight of 3½ pounds each, were taken in 5 pound nets set in this river. In 1896 there were 3 pound nets set at the head of the river, near the Massachusetts State line. The shad season began April 20 and ended May 29, and the catch numbered 5,480 roes and 3,778 bucks, valued locally at $2,408. This was an average for recent years, the yield ranging from 6,000 to 12,000 annually.

Pawcatuck River.—The Pawcatuck formerly yielded a large number of shad, but at present it is obstructed by numerous dams, which completely block the passage of fish. Yet a few shad are taken in the

lower portion of this river each year, as well as in Old Warwick Cove and Patowomut River, the aggregate yield in these waters averaging about 400 annually, taken by means of seines, dip nets, etc.

Providence-Blackstone River.—The numerous dams and the sewage from the city of Providence have served to almost exterminate shad from Providence-Blackstone River. But each year a few hundred are taken by seines, dip nets, and other contrivances, the yield in 1896 being estimated at 500 in number.

Greenwich Bay.—Two seines hauled in Greenwich Bay in 1896 caught 108 roe shad and 52 bucks, which sold for $49.

THE SHAD FISHERIES OF MASSACHUSETTS.

There are no regular shad fisheries in Massachusetts, this species being caught only incidentally in connection with the taking of other fishes. The following table shows, by water areas, the yield of shad in each form of apparatus operated in this State in 1896:

Waters.	Drift nets.		Seines.		Pound nets.		Total.	
	No.	Value.	No.	Value.	No.	Value.	No.	Value.
Taunton River			3,355	$934			3,355	$934
Buzzards Bay					721	$252	721	252
Vineyard Sound					2,664	582	2,664	582
Cape Cod Bay	22,080	$691	9,080	454	1,745	304	32,905	1,449
Massachusetts Bay					170	17	170	17
Merrimac River			7	2			7	2
Total	22,080	691	12,442	1,390	5,300	1,155	39,822	3,236

TAUNTON RIVER.

This river is formed by the union of Satucket and Matfield rivers in Bridgewater, Mass., whence it flows to its entrance into Narragansett Bay. It is navigable for 18 miles to East Taunton, where it is crossed by a dam, developing a fall of 9 feet of water. Shad enter Taunton River about the latter part of March and remain until some time in June, although few are taken after the end of May. It does not appear that there have ever been important fisheries in this river dependent exclusively upon shad, and during recent years that species has been taken only incidentally in connection with the alewife fisheries. The following summary shows for recent years the total yield of shad in this stream:

Year.	Number of seine fisheries.	Number of shad caught.	Year.	Number of seine fisheries.	Number of shad caught.
1878	13	7,308	1888	10	6,353
1879	9	3,009	1889	13	7,329
1880	11	6,615	1890	10	4,836
1881	10	5,739	1891	9	2,451
1882	11	11,173	1892	12	2,056
1883	11	5,012	1893	6	2,104
1884	10	4,037	1894	9	2,814
1885	10	4,964	1895	8	3,804
1886	8	2,620	1896	8	3,355
1887	8	4,550			

In 1880 there were 15 seines used in Taunton River, requiring the services of 108 men, and their catch of shad was reported at 6,615, weighing 21,498 pounds. The yield of alewives during the same season numbered 1,718,000. In 1896 there were 8 fisheries for alewives, at which 13 seines were used, with an aggregate length of 1,903 yards and valuation of $1,478. These required the services of 87 fishermen and 22 shoresmen, and their catch of shad numbered 3,355, worth $934, and of alewives 1,898,478, valued at $9,478.

BUZZARDS BAY.

In this coastal indentation, covering 225 square miles on the southern shore of Massachusetts, there are a few shad taken each year incidentally in the pound nets set primarily for alewives, scup, butterfish, etc. These nets are set along the shore west of Apponagansett Bay, at the mouth of Pamansett River, between that river and Goose Neck, and on Elizabeth Islands. The number used in 1896 was 35, valued at $11,550, and the season extended from early in April to some time in November, shad being taken during April and May. The yield of shad was 721, valued at $252, while the alewives taken in the same nets numbered 258,875, worth $1,380. A State law interdicts the use of pound nets in Buzzards Bay after the expiration of the permits granted prior to the enactment of that regulation. These privileges expire at the end of the season of 1897, and after that date there will probably be no fishing in this locality except that with hand lines and the clam and scallop fisheries.

Vineyard Sound.—In the Vineyard Sound pound-net fishery there are a few shad taken each year, the yield in the 42 nets operated in the spring of 1896 being 2,664, valued at $582. The same nets caught also 320,165 alewives, which sold for $1,525. Shad are first taken in these nets about April 20, and few are caught after May 15.

CAPE COD AND MASSACHUSETTS BAY.

The principal shad yield in Massachusetts is obtained by the mackerel fishermen from Provincetown, each of the small vessels engaged in drifting mackerel nets from that port taking a few shad incidentally during the month of June, the yield usually ranging from 600 to 1,200 shad annually to each vessel. The vessels engaged in this fishery measure from 5 to 15 tons, are manned by two or three men each, and carry from 25 to 45 nets, averaging 60 yards in length, with from 3 to 3½ inch mesh. In 1896 there were 27 small vessels engaged in this fishery, with an aggregate measurement of 341 tons and valuation of $21,950. These vessels were operated by 58 men and carried 791 nets, 47,453 yards in length, valued at $7,910, and the total catch of shad was 19,040, for which the fishermen received $596. These shad were unusually small, averaging only about 2 pounds each, due to the small mesh of the nets. Seven Provincetown sailboats, worth $1,300, manned by 14 men, and carrying 150 mackerel drift nets similar to those used

on the small vessels, caught a few shad in 1896, their entire yield being 3,040, which sold for $95.

Occasionally Provincetown boats catch some shad while seining for mackerel. In 1896 the steamer *Cormorant*, 4.81 net tonnage, made three hauls of shad, one each on June 6, 7, and 9, catching 9,080, which were sold fresh at 5 cents each.

The pound nets and weirs set in Cape Cod Bay catch a few shad, the number taken ranging upward to 50 or more to each net. In 1896 85 nets set in this bay took 1,745 shad, valued at about $300.

Comparatively few of the trap nets set in Massachusetts Bay catch shad; in 1896 only 5 are reported as having taken this species, the total yield being 170, worth $17.

MERRIMAC RIVER.

The sources of the Merrimac are in eastern central New Hampshire, the main stream being formed by the junction of the Pemigewasset and Winnipesaukee rivers, on the line of Belknap and Merrimac counties, whence it flows 110 miles to its entrance into the sea near Newburyport. The head of navigation for coasting vessels is a few miles above Haverhill, but small river boats ascend as far as Lawrence. At Lawrence the stream is crossed obliquely by a substantial dam 32 feet high and 900 feet long, at the south end of which is a wooden fishway, the whole being completed in 1848 at a cost of about $250,000. At Lowell, 12 miles above Lawrence, there is a second dam about 30 feet high, built in 1830 and enlarged in 1876. A third dam exists at Manchester, N. H., constructed in 1871, its length being 420 feet and its height about 12 feet. There are three other dams on the river above Manchester, viz, at Hooksett, Garvin Falls, and Sewell Falls.

Previous to the erection of these obstructions there were large runs of shad and other anadromous fish into and up the Merrimac. It is claimed that at the junction of the two head tributaries, the Pemigewasset and the Winnipesaukee, the shad and salmon separated, the former following the eastern branch into Lake Winnipesaukee, while the latter ascended the colder waters of the Pemigewasset, penetrating its source in the White Mountains.

In a report[1] of special commissioners of Massachusetts, appointed in 1865, "concerning the obstructions to the passage of fish in the Connecticut and Merrimac rivers," the following approximation of the yield of shad in the Merrimac is given:

Year.	Estimate for river below Pawtucket Falls.	Estimate for Pawtucket Falls.	Total.	Value, at prices prevailing in 1865.
1789	700,000	130,000	830,000	$138,300
1805	450,000	90,000	540,000	90,000
1835	306,000	59,000	365,000	60,000
1865	50,000	....	50,000	8,500

[1] Report of the Commissioners, Senate, No. 8, 1866, p. 39.

Since the erection of the Lawrence and Lowell dams the run of shad in the Merrimac has been constantly decreasing, as appears from the following summary, covering a period of nineteen years:

Year.	Number of seines.	Number of shad reported.	Number taken in Amesbury seine.	Year.	Number of seines.	Number of shad reported.	Number taken in Amesbury seine.
1878	7	5,033	2,836	1888	1	....	....
1879	8	2,781	1,757	1889	5	18	....
1880	7	2,139	1,478	1890	6	....	....
1881	6	1,192	704	1891	3	....	....
1882	4	387	282	1892	2	....	....
1883	2	146	57	1893	4	2,020	....
1884	2	111	....	1894	3	2,750	....
1885	2	130	86	1895	6	94	....
1886	1	73	....	1896	7	7	....
1887	1	28	....				

THE SHAD FISHERIES OF MAINE.

The extent by water areas of each branch of the shad fisheries of Maine is presented in the following series of three tables, showing for 1896 (1) the number of persons employed; (2) the boats, apparatus, etc., used, and (3) the quantity and value of the catch.

Statement of the number of persons employed in each branch of the shad fisheries of Maine in 1896.

Waters.	Drift-net.	Seine.	Weir.	Total, exclusive of duplication.
Casco Bay	20	*a* 11	....	31
Kennebec River	72	....	118	178
Androscoggin River	5	4	4	11
Eastern River	6	....	24	30
Harrington River	6	....	....	6
Pleasant River	15	....	....	15
Total	124	15	146	271

a Purse-seine fishermen.

Statement of the boats, apparatus, etc., employed in the shad fisheries of Maine in 1896.

Waters.	Boats.		Drift nets.			Seines.			Weirs.		Value of shore property.	Total value.
	No.	Value.	No.	Length.	Value.	No.	Length.	Value.	No.	Value.		
				Yards.			*Yards.*					
Casco Bay	19	$4,224	64	4,228	$885	*a* 1	320	$350	....	....	....	$5,459
Kennebec River	209	6,483	107	10,838	1,568	....	....	....	114	$20,400	$5,971	34,422
Androscoggin River	6	65	5	400	75	1	90	20	2	125	50	335
Eastern River	27	662	12	900	102	....	....	....	17	2,815	817	4,396
Harrington River	6	30	9	540	54	....	....	....	....	....	....	84
Pleasant River	14	178	31	1,860	186	....	....	....	....	....	....	364
Total	281	11,642	228	18,766	2,870	2	410	370	133	23,340	6,838	45,060

a Purse seine.

Statement of the yield of shad in Maine in 1896.

Waters.	Drift nets.		Seines.		Traps and weirs.		Total.	
	No.	Value.	No.	Value.	No.	Value.	No.	Value.
Casco Bay	6,110	$355	40,325	$2,017	18,055	$1,208	64,490	$3,580
Kennebec River	45,787	5,026			205,542	17,780	251,329	22,806
Androscoggin River	1,530	138	5,500	495	6,380	574	13,410	1,207
Eastern River	3,000	270			22,383	1,974	25,383	2,244
Penobscot River					114	27	114	27
Harrington River	3,000	192					3,000	192
Pleasant River	9,000	720					9,000	720
St. Croix River					12	2	12	2
Total	68,427	6,701	45,825	2,512	252,486	21,565	366,738	30,778

SACO RIVER.

This river has its sources among the White Mountains, nearly 100 miles from its entrance into the ocean near Biddeford Pool. At Biddeford, 6 miles from the sea, there are two falls, each about 16 feet high. From that point to Hiram Falls, 45 miles from the sea, there are no less than 8 dams, each from 6 to 14 feet high, and at Hiram Falls the river descends 80 feet in five successive plunges. Formerly shad abounded in the lower end of the river, but it does not appear that they passed above Biddeford Falls, though salmon ascended as far as Hiram Falls. During recent years no shad have been reported from Saco River.

CASCO BAY.

Shad have been caught in Casco Bay more or less extensively for the last forty or fifty years, but the yield has fallen off considerably during recent years. They appear in these waters about May 1, and are observed to some extent as late as the end of September. These shad are smaller and presumably younger than those running up the rivers, and are commonly known as "sea shad." Of the 64,490 taken during 1896, 6,110 were caught with drift nets, 40,325 with seines, and 18,055 with trap nets and weirs.

Gill nets are used mostly in Quahog Bay and the coves of Harpswell Sound, near the northeastern end of Casco Bay. They range in length from 60 to 75 yards each, 35 to 45 meshes deep, with from 4 to 4¾ inch mesh. Most of the nets are drifted in the current of the long, narrow bays or sounds, but at times they are set near the mouths of the coves. In 1896 there were 64 gill nets in Casco Bay, aggregating 4,228 yards in length and $885 in value, requiring 18 boats, manned by 20 men. From June 20 to August 31 they caught 6,110 shad, valued locally at $355. About one-fourth of these were salted, the remainder being sold fresh.

The trap nets and weirs in the eastern half of Casco Bay take many small shad each season, the largest catch being obtained in those between Small Point and the mouth of New Meadows River. The nets are set from early in the spring until late in the fall, and their yield of shad is obtained at intervals from the first of May until late in September. In 1896 there were 46 pound nets, trap nets, and weirs in those waters, the value approximating $12,840. They required the services of 88 men and $5,347 worth of boats, and yielded 18,055 shad, valued

locally at $1,208. During June and July, 1896, the schooner *Robert and Carr*, 51.85 tons, of Cundys Harbor, fished for shad with a mackerel purse seine in Casco Bay and east thereof. The seine was of the ordinary type used in the mackerel fishery, 320 yards long, 36 yards deep, with 2-inch mesh. The yield numbered 40,325, which were salted, filling 322 barrels, and sold mostly in Portland at $6.25 per barrel.

KENNEBEC RIVER.

This river has its sources in Moosehead Lake, the largest body of fresh water in Maine, at an elevation of 1,023 feet above sea level; thence it flows in a general southerly direction 155 miles to its entrance into the sea immediately east of Casco Bay. It is tidal and navigable for large vessels from the mouth to Augusta, a distance of 44 miles. Nine miles below Augusta it receives its principal tributary, Androscoggin River, and expands into a wide area known as Merrymeeting Bay. At that point the water is usually fresh, but when the river is low it is brackish as far as Richmond. At Augusta the Kennebec is crossed by an insurmountable crib dam 17 feet high and 956 feet long, rebuilt in 1870. A fishway has been placed in this dam at its eastern end, but it does not appear to be used by shad. A second dam at Waterville, 17 miles above Augusta, was built in 1869, and is 7 feet high and 750 feet in length. There are several dams above Waterville, the principal ones of which are at Kendall Mills, Somerset Mills, Skowhegan Falls, Norridgewock, Madison Bridge Falls, etc.

For half a mile or more immediately below the Augusta dam there are gravelly shoals which afford suitable spawning areas for shad; hence the erection of that dam has not been so injurious to this species as to the salmon. Merrymeeting Bay, by reason of its broad, sandy flats, is also a favorable place for shad spawning. The greatest injury to shad in the Kennebec has been the vast quantities of sawdust run into the river from numerous sawmills, covering the river bottom in many places, so that areas formerly eligible for spawning-grounds are no longer suitable. The fishermen state that this refuse is so abundant in Merrymeeting Bay that at times the bottoms of their weirs are covered several feet therewith.

Shad formerly ascended Kennebec River as far as Norridgewock Falls, 84 miles from the sea, where they turned aside into a small tributary known as Sandy River. At Ticonic Falls and at Skowhegan there were productive dip net fisheries. It is on record that at the former place four men dipped 6,400 shad in one day, and that 1 man, with the assistance of 3 boys, caught 1,100 shad and 20 salmon in one afternoon. The catch in a weir at Abagodasset Point for several years following 1820 ranged from 3,000 to 10,000 annually.[1] A weir operated in Merrymeeting Bay yielded during the ten years ending in 1835 an average of 5,961 shad annually, while in the eleven years from 1837 to 1848 (omitting 1844, the record for which is lacking), the aver-

[1] Fishery Industries of United States, sec. V, vol. I, p. 719.

age was 3,120 per year. In 1867 the catch of shad by 40 weirs, several seines, and an unknown number of drift nets was 180,000. In 1880, 44 weirs, 2 seines, and 60 or more drift nets took 105,000 shad. At present the shad fisheries of Kennebec River are the most important on the Atlantic coast north of Hudson River, and the yield is greater than in all the remaining waters of the New England States. They extend from the mouth of the river nearly to Augusta, the forms of apparatus employed being weirs and drift nets. The catch in 1896 by the weirs numbered 205,542 and by drift nets 45,787, making a total of 251,329, valued at $22,806. The yield of shad in 1867 was estimated at 225,000, of which 200,000 were taken in weirs and 25,000 in other forms of apparatus.

The weir fishery is carried on in the Kennebec chiefly between Iceboro, about 3 miles above Swan Island, and the Chopps, a narrow part of the river below Swan Island. In addition thereto there are a few weirs in the vicinity of South Gardiner and 3 or 4 in the lower part of the river below Bath. In Merrymeeting Bay there are numerous weirs, and a number in Eastern and Androscoggin rivers, which enter the Kennebec at Merrymeeting Bay. The following description of these weirs is furnished by Mr. Ansley Hall:

In form of construction these weirs are similar to the ordinary pound nets, but they are operated on the principle of brush weirs. They cost from $10 to $40 each, according to their size. Instead of lifting them to remove the fish a seine of 1¾-inch mesh is used for that purpose. The seine has a staff at each end and is furnished with purse lines. It is about 25 feet in length and varies in width according to the depth of the water in the weir in which used. If two or more adjacent weirs are of about the same size and depth, one seine may be used for them all; otherwise there is a seine for each weir. The leader of each weir consists of stakes driven about 18 inches apart and interwoven at the top with maple sprouts or brush to form a sort of binder for support. Where the tide is unusually strong large stakes are driven a short distance from the leader stakes and the leader guyed to them with lines. The length of the leaders varies according to the width of the river, but where the stream is of sufficient width it is 100 feet or more, but it is usually from 50 to 100 feet. From a point near the shore, where the water is about 2 feet deep at low tide, the leader may be extended a distance not greater than one-eighth of the width of the river channel. The weir has three pounds, viz, the big or pasture pound, the second pound, and the fish pound. The big pound is at the end of the leader and the other two are always on the down-river side of the big pound. The depth of water in which the pounds are located varies from 18 to 30 feet at low water, but is ordinarily about 22 feet, except in Merrymeeting Bay and the tributary streams, where the depth is less. The stakes forming the pound are from 20 to 45 feet in length, depending on the depth of water. They are driven 3 or 4 feet apart and twine with 2½ or 3 inch mesh is hung on the outside of them, this twine being sufficiently deep to extend about 1 foot above the surface at high water. An iron chain is attached to the lower edge of the twine to keep it close to the bottom of the river. The principal part of each pound is made with a single piece of netting. The length of the netting in the big pound is from 140 to 145 feet, in the second pound about 100 feet, and in the fish pound from 135 to 140 feet. Small stakes are driven outside the twine and bound to the large stakes with cords at intervals as far down as practicable, thus serving to hold the twine in place. The weir is braced by guy lines made fast to piles (known as "pointers") driven on the upper side of the big pound. The cost of a completed weir varies from $100 to $800, averaging perhaps $200.

The boats used in the weir fishery are flat-bottomed skiffs, about 15 feet long and square at each end, this form being the most convenient for operating the small seine. Large scows, 20 to 30 feet in length, are used in building the weirs and sailboats are employed in transporting the fish caught. In 1896 there were 114 weirs, valued at $20,400, operated on the Kennebec by 118 men, using 209 boats, valued at $6,483. The season for shad began about May 1 and ended about June 25, the catch numbering 205,542, valued locally at $17,780.

Drift nets are operated in Kennebec River from the mouth to Merrymeeting Bay, but most extensively in the vicinity of Bowdoinham, North Bath, Bath, and Georgetown. The length of these nets ranges from 200 to 400 feet, averaging slightly more than 300 feet. The mesh varies from 4⅝ to 5¼ inches, the mesh of those operated below Bath being a trifle smaller than those above that town. The drift-net season is coincident with the season in which shad are taken in the weirs, and extended in 1896 from May 1 to June 25. During that year there were 47 boats employed in this branch of the shad fishery, manned by 72 men and using 107 drift nets, aggregating 10,838 yards in length and $1,568 in value. The catch numbered 45,787 shad, valued at $5,026.

Androscoggin River.—This river, the principal tributary of the Kennebec, has its sources partly in Maine and partly in New Hampshire, whence it flows 160 miles to its entrance into the broad expanse of Kennebec River, known as Merrymeeting Bay. It is navigable for a distance of 6 miles from the mouth to the falls at Brunswick, where it is crossed by two dams, each about 14 feet high. At Lisbon Falls, 8 miles above Brunswick, there is a dam 10 feet in height. At Lewiston, 40 miles by the river course from the ocean, there is a natural fall of 38 feet in a distance of 600 feet, at the head of which there is a dam with an average height of 12 feet. At present the shad fisheries of the Androscoggin are confined to the lower end below Brunswick Falls. Of the 13,410 shad taken on this river in 1896, 5,500 were caught in a seine, 1,530 in 5 drift nets, and 6,380 in 2 weirs. The seine was 90 yards in length with 3¼-inch mesh, and was operated during the month of May and the first three weeks of June. The drift nets were 80 yards in length with 3¼-inch mesh, and were used by one man each, the season being coincident with that of the seine fishery. The two weirs were much smaller than those in Kennebec River, both of them being valued at only $125, and required four men to operate them.

Eastern River.—In Eastern River, which enters the Kennebec a short distance below Richmond, there are quite a number of shad taken by weirs and a few by drift nets. The first report of the commissioner of fisheries of the State of Maine states:

> In Eastern River thirty years ago there were 8 or 9 weirs, each of which took 6,000 or 8,000 shad per year, and about the same amount was taken by seines and drift nets, indicating a catch of 100,000 shad annually. In 1846 one seine took 4,719 shad; in 1847, 3,319, and in 1852, 2,500.—(Reports of the Commissioners of Fisheries of Maine for 1867 and 1868, p. 46.)

The weirs used in 1896 were smaller than those on the Kennebec, but resembled them in every other particular. Seventeen were set in the lower end of this tributary, approximating $2,815 in value, and yielding 22,383 shad, valued locally at $1,974. These weirs also caught 60,216 alewives, worth $448. Six drift-net boats were used on Eastern River, manned by an equal number of men and using 12 nets, aggregating 900 yards in length, with 5⅛-inch to 5¼-inch mesh. Their catch from May 1 to June 25 numbered 3,000 shad, valued at $270.

East of the Kennebec River there are no established runs of shad up any of the rivers of the United States. They appear to pass northward along this stretch of coast during May and June, and to return southward in August and September. During both the spring and the fall run, especially the latter, small schools enter the bays and the lower estuaries of the rivers. In only a few localities, however, do they appear with sufficient regularity to induce fishermen to make special preparation for them, among which are Harrington and Pleasant rivers. In other localities, as Penobscot Bay, Dyer Bay, Narragaugus Bay, etc., they are taken incidentally in brush weirs and other apparatus set for herring, etc.

PENOBSCOT RIVER AND BAY.

This stream is the largest on the United States coast north of the Connecticut. Its sources are in the extreme western part of Maine near the Canadian boundary, whence it flows a distance of over 200 miles to its entrance into Penobscot Bay, 30 miles below Bangor. It is navigable for large vessels from the mouth to Bangor, a short distance above which it is crossed by a dam 10 feet in height. Within the next 12 miles the fall of the river approximates 70 feet, an average of nearly 6 feet per mile. Four miles above the first dam there is a second dam 8 feet in height, and above this point there are numerous other obstructions.

It is stated that originally shad was the most abundant fish in the Penobscot. At Oldtown Falls, a short distance above Bangor, there were extensive fisheries eighty years ago, which yielded far more shad than was necessary for the local demand, the price averaging but $1 per 100. On the lower part of the river many shad and salmon were caught in weirs and sold to the vessels, mostly from Connecticut, which made annual trips to this river for salt fish. There was little decrease in the abundance until the erection of the dam a short distance above Bangor in 1830. Then came the erection of the Great Works dam, and in 1834 the Veazie dam was built. When the shad came up in the spring of 1835 and found the impassable barrier to their further progress they wandered in confusion below the obstruction, and many loaded with ripe spawn were taken in weirs in the town of Bucksport, which was reported as a most unusual occurrence. The Penobscot, unlike the Kennebec, has no available spawning-grounds below the dams, and furthermore the water is frequently brackish all the way to Bangor, and whatever

spawning-grounds would be otherwise available in the Penobscot are covered with sawdust. During the few years following the construction of the dams shad were taken in abundance in the lower end of the river, then they decreased, and within a few years more they were comparatively scarce. In 1867 the yield of shad in the Penobscot had decreased to 5,000. Mr. S. B. Rich, of Bucksport, fished with a drift net about 1830, and would sometimes catch 300 shad in a single night; in 1867 he tried it again, but caught no more than 3 shad in any one night, and sometimes 2, 1, or none. The decrease in yield of shad in these waters has continued up to the present time, the entire yield in Penobscot River and Bay in 1896 being only 114 shad, worth $27, all of which were caught in weirs set in the vicinity of Whitmore Island.

PLEASANT AND HARRINGTON RIVERS.

On Pleasant River shad have been caught to a greater or less extent during the past thirty years, and for the last ten years from 5,000 to 10,000 have been taken annually by drift nets. In 1896 there were 14 boats, worth $178, and manned by 15 men, engaged in drifting nets on this river near the town of Addison. The nets used numbered 31, with an aggregate length of 1,860 yards and value of $186, the mesh being 4¾ inches. The season extends from July 1 to September 15, and the catch of shad numbered 9,000, worth $720.

In Harrington River there were 6 men who caught shad in 1896, using 6 boats, worth $30, and 9 drift nets, 540 yards in length, with 4¾ inch mesh, worth $54. The catch approximated 3,000, most of which were salted and sold at $8 per barrel.

LIST OF FISHES

COLLECTED AT THE

REVILLAGIGEDO ARCHIPELAGO AND NEIGHBORING ISLANDS.

BY

DAVID STARR JORDAN AND R. C. McGREGOR.

LIST OF FISHES COLLECTED AT THE REVILLAGIGEDO ARCHIPELAGO AND NEIGHBORING ISLANDS.

By David Starr Jordan and Richard Crittenden McGregor.

In March, 1897, the schooner *H. C. Wahlberg*, Capt. A. W. Anthony, set out from San Diego, California, on a collecting expedition to the islands off the west coast of Mexico, the principal purpose being the exploration of Clarion and Socorro, which islands, with other smaller ones, compose the Revillagigedo Archipelago. Mr. R. C. McGregor, a student in zoology in Leland Stanford Junior University, went with the vessel as assistant naturalist. Among other things he obtained a fine collection of fishes, most of them secured by the use of dynamite among the rocks of Clarion and Socorro islands. A very few of the fishes were taken in an improvised seine; no dredge was used.

Collections were made at the following localities: Ensenada, March 6; Todos Santos Island, March 10; San Martin Island, March 12; San Geronimo Island, March 15; Guadalupe Island, March 23; San Benito Island, March 27; Cerros Island, April 4; Abreojos Point, April 19; San Jose del Cabo, April 23. Finally, nearly the whole month of May was devoted to collecting about San Benedicto, Socorro, and Clarion islands.

Six new species were obtained, as follows:

Myrichthys pantostigmius, Clarion Island, 5710, L. S. Jr. Univ. Mus.
Zalocys stilbe, Clarion Island, 11996, L. S. Jr. Univ. Mus.
Apogon atricaudus, Socorro Island, 5708, L. S. Jr. Univ. Mus.
Forcipiger flavissimus, Clarion Island, 5709, L. S. Jr. Univ. Mus.
Cantherines carolæ, Socorro Island, 11995, L. S. Jr. Univ. Mus.
Azurina hirundo, Guadalupe Island, 5706, L. S. Jr. Univ. Mus.

These species are also described in Jordan & Evermann's Fishes of North America.

The fauna of the outlying islands of Mexico and Ecuador contains a number of species properly belonging to the fauna of the East Indies. Few of these oriental types reach the coast of Mexico or Panama, the coast fauna in general being analogous to that of the West Indies. Among the forms not found along the mainland, and identical or nearly identical with East Indian species, are the following, those here recorded for the first time from American waters being printed in italics:

Lycodontis pictus.
Caranx orthogrammus.
Caranx lugubris.
Kuhlia arge (tæniura).
Priacanthus carolinus.
Evoplites viridis (kasmira).
Kyphosus lutescens.
Forcipiger flavissimus (longirostris).
Zanclus cornutus.
Teuthis triostegus.
Teuthis aliala.
Melichthys bispinosus.
Xanthichthys mento.
Cantherines carolæ (pardalis).
Ovoides setosus.

A full series of the specimens taken, including the types of the new species, has been presented to the Leland Stanford Junior University through the Hopkins' Seaside Laboratory, under the auspices of which Mr. McGregor carried on his work. The rest of the collection has been sent to the British Museum, the museum at Vienna, the U. S. Fish Commission, and the U. S. National Museum.

Family GALEIDÆ.

1. **Mustelus lunulatus** Jordan & Gilbert. One specimen, a yard long, from Ensenada, Lower California, March 6. The first dorsal fin is lower and both dorsals and pectorals less incised than in the type of the species. The snout is also somewhat shorter and broader. All these may be characters of increased age, as the specimen is larger than any of those originally described.
2. **Carcharhinus platyrhynchus** (Gilbert). Two young individuals from Clarion Island.
3. **Galeorhinus zyopterus** Jordan & Gilbert. One young example from Ensenada harbor.

Family DASYATIDÆ.

4. **Urolophus halleri** Cooper. One specimen from Ensenada, Todos Santos Bay.

Family OPHICHTHYIDÆ.

5. **Ophichthus triserialis** (Kaup). One example, 25 inches long, Abreojos Point, Lower California.
6. **Myrichthys pantostigmius** Jordan & McGregor, new species. (Plate 4.)

Head $4\frac{4}{5}$ in trunk; head and trunk $1\frac{1}{3}$ in tail; cleft of mouth 3 in head; eye $2\frac{2}{3}$ in snout, which is 5 in head. Pectorals 2 in snout. Anterior nasal tube equal to eye. Color olivaceous, with distinct rows of roundish blackish spots, some oblong, smaller on head and covering whole belly; 39 spots in dorsal row, these spots usually alternating each with its fellow on the other side of dorsal, but sometimes opposite; spots of second row usually opposite; spots of third row smaller and more numerous, extending from the cheeks to opposite the vent, thence running along base of anal, not running on fin, most of this row little more than half length of snout; two rows of smaller spots along belly from gill-opening to front of anal; spots on nape rather large, on head larger and more numerous than in *Myrichthys xysturus*. Pale color of head reduced to reticulations; chin and throat spotted as much as head; no pale centers to any of spots; dorsal without spots or with only a few which come up from back; from beginning to end the dorsal has a broad black margin about one-third height of fin; anal mostly pale, but having some black markings toward tip; pectoral with upper half jet-black—a white margin posteriorly—a small black spot in lower corner.

One specimen, 20 inches long, from Clarion Island; type number 5710, Leland Stanford Junior University Museum.

This species is distinguishable from all others by the great number of spots of small size and without pale centers, the black edge of dorsal, the black spot on the rather large pectoral, and especially by having the belly spotted as much as the other parts.

Family MURÆNIDÆ.

7. **Lycodontis pictus** (Ahl). Head 4 in trunk; tail about as long as body; eye $2\frac{1}{2}$ in snout, situated midway between snout and angle of mouth; cleft of mouth $2\frac{2}{3}$ in head; snout $5\frac{2}{3}$ in head; anterior nasal tube 5 in snout; gill-opening 11 in head. Teeth in each jaw in a single series; palatine series either parallel with these or divergent; no distinct canines; teeth comparatively small;

anterior vomerine one or two in number, bluntish and conical; posterior vomerine teeth rather blunt. Anterior nasal tubes moderate. Dorsal low anteriorly, beginning in front of gill-opening.

Color brownish-gray or purplish, everywhere covered with small purplish-black spots which are not confluent. In adults the spots are arranged in roundish or ringlike blotches on the sides; fins colored like body, without dark edges.

Two specimens, each about 3 feet long, taken at Clarion Island seem to correspond in full with figures given by Dr. Bleeker of this common East Indian species.

8. **Echidna nocturna** (Cope). The smallest specimen measures 20 inches and is unspotted except for a few faint yellow markings near end of tail. The largest example measures a yard in length. Teeth of lower jaw blunt, subequal and biserial, in upper jaw larger and irregularly biserial. Directly under front of eye these teeth become regularly biserial, much smaller, and more pointed; two regular rows of blunt vomerine teeth. Dorsal high, beginning over gill-opening; eye $2\frac{3}{4}$ in snout; head $3\frac{1}{5}$ in trunk; cleft of mouth $3\frac{1}{2}$ in head; tail shorter than rest of body by distance from cleft of mouth to gill-opening. Color seal brown, belly lighter, covered everywhere with irregular spots and points of yellow, the largest about $\frac{1}{8}$ inch across. Lower jaw heavily mottled with yellow; no black margins to spots. Eight specimens were collected among rocks in tide pools at Clarion and Socorro islands.

Family EXOCŒTIDÆ.

9. **Exocœtus volitans** Linnæus.

Halocypselus evolans (Linnæus).

Numerous specimens taken from the Gannets of the Revillagigedo Islands.

10. **Exonautes xenopterus** (Gilbert). One large specimen from Clarion Island—another off Morro Hermoso, Lower California.

Family MUGILIDÆ.

11. **Mugil curema** Cuvier & Valenciennes. An abundant species at Socorro Island. Four specimens.

12. **Chænomugil proboscideus** (Günther). Young and large individuals abundant at Socorro Island.

Taken commonly in large tide pools with *Kuhlia arge*. Some of the smaller specimens have the pectorals and anal colorless; others have a smaller mouth and thinner lips, but these characters are not coordinated with any other differences. All probably belong to one species.

Family HOLOCENTRIDÆ.

13. **Holocentrus suborbitalis** Gill. Clarion Island and Socorro Island; twelve large examples taken similar to others from Mazatlan.

14. **Myripristis clarionensis** Gilbert. Five large examples from Clarion and Socorro islands, similar to original types.

Family MULLIDÆ.

15. **Upeneus dentatus** Gill.

Upeneus dentatus Gill, Proc. Ac. Nat. Sci. Phila. 1862, 256.

Upeneus xanthogrammus Gilbert, Proc. U. S. N. M. 1891, 553.

A 6-inch specimen from Clarion Island. Teeth in bands anteriorly; uniserial behind; scales 38. This specimen certainly belongs to *U. dentatus*. We can not separate *U. xanthogrammus* from it.

Family LEPIDOPODIDÆ.

16. Lepidopus xantusi Goode & Bean.

Lepidopus caudatus Jordan & Gilbert, Proc. U. S. N. M. 1882, 358, Cape San Lucas; not of Euphrasen.

Lepidopus xantusi Goode & Bean, Ocean. Ichth., 519, 1896; same type; no description.

Head 4⅗ in body; depth 3 in head; eye 5½; interorbital space 8½; snout 3; maxillary 3⅓; D. 82; A. II, 45. Jaws with long, sharp teeth in front, followed by single rows of weaker ones arranged in groups of twos and threes. Height of dorsal, near middle of body, 3 in head. Anal preceded by 2 scutes, the first minute, the second wide, strongly keeled, its length ⅘ diameter of eye. Pectoral of 12 rays, its length 2 in head. Each ventral consists of a flat, keeled spine followed by a minute ray. This species is known from two small mutilated specimens, both found on the beach near San Jose del Cabo, Cape San Lucas. The type was taken by John Xantus about 1860, and recorded by Jordan & Gilbert in 1882 as *Lepidopus caudatus*. The second, of about the same size (5½ inches), was taken by Mr. McGregor in 1897. From the latter the above account was taken. The species differs from *Lepidopus caudatus* in the much shorter dorsal and longer anal. (D. 103; A. 24, besides rudiments, in *L. caudatus*.)

Family CORYPHÆNIDÆ.

17. Coryphæna equisetis Linnæus. Head 4½; depth 5; D. 51; A. 24. Eye 3½, large, without adipose eyelid. Nostril in middle of snout, vertically oblong, rather small, anterior opening scarcely visible. Snout bluntish, 3⅗. Mouth slightly oblique; maxillary 2½ in head; narrow at tip, without distinct supplemental bone. Preorbital very narrow, 4 in head. Jaws each with a broad band of small, sharp, rather wide-set teeth; bands of villiform teeth on vomer, palatine, and tongue. Body elongate, little compressed, formed as in a mackerel; head broad above, with a conspicuous crest. No pseudobranchiæ; branchiostegals subtruncate; opercles strongly striate. Dorsal beginning near opercle, posterior ray longest, last few rays pencil-like, resembling finlets, but not divided at base; anal without evident spine, first rays longest, 5 in head, last rays slightly free at tip, but less so than in dorsal; caudal peduncle slender, rather long; caudal lobes long and sharp, about as long as head; ventrals long, depressible into a deep groove on abdomen, 1⅗ in head; ventral rays I, 5; pectoral very short, falcate, 1¼ in head. Scales cycloid, more or less elongate on each side of head, along base of anal more or less bony, elongate and spine-like, closely imbricated; along ventral groove and other lower parts somewhat similarly modified; lateral line somewhat undulate and a little arched in front. Color dark blue-black above, lower parts paler and nearly uniform.

This specimen is probably the young of *Coryphæna equisetis*. It seems to differ from *Coryphæna equisetis* as described, in color, in not having an angulation in lateral line, in the longer head, in having the opercle striated for its whole length, in elevated last rays of dorsal, and possibly in modified scales of belly.

One specimen, 9 inches long, from San Benedicto Island.

Family CARANGIDÆ.

18. Trachurops crumenophthalmus (Bloch). Six specimens from Socorro Island.

ZALOCYS Jordan & McGregor, new genus.

This genus is closely allied to *Hypodis* Rafinesque (=*Lichia* Cuvier), differing in the absence of a procurrent spine before the dorsal, in the cultrate thoracic region, and in the weaker teeth. *Hypodis* is scarcely different from *Trachi-*

notus, the only characters tangible being the larger teeth, low dorsal, and less elevated forehead. The distinctions between *Hypodis* and *Trachinotus* are of little value. *Porthmeus* (=*Lichia amia* and *L. radigo*) is a well-defined genus, distinguished by the large mouth and projecting lower jaw.

19. **Zalocys stilbe** Jordan & McGregor, new species. (Plate 5.)

Head $4\frac{1}{5}$; depth $2\frac{1}{2}$; D. VI, I–26; A. II, I–23. Body elliptical, deeper than in *Hypodis glaucus*; belly sharply compressed; ventral outline similar to that of dorsal. Anterior profile of head elevated and sharp, the eye being rather below than above its middle. Eye 5 in head, with conspicuous adipose eyelid before and behind; posterior nostril much larger than anterior, vertically oblong; maxillary broad, without supplemental bone, extending to pupil, $2\frac{5}{8}$ in head. Mouth moderate, oblique; each jaw with bands of villiform teeth; similar teeth on vomer, palatines, and tongue. Preopercle very broad; cheek moderate; suborbital narrow; preorbital very narrow, 4 in eye. No pseudobranchiæ. Gillrakers very long and slender, numerous. No procumbent spine before dorsal. Spines low and separate; spines progressively higher. Soft dorsal and anal each with a sheath of scales. First rays of dorsal very slightly elevated, $2\frac{1}{3}$ in head; anal without distinct anterior lobe, longest ray $2\frac{3}{4}$ in head; caudal peduncle long and slender, its depth $3\frac{3}{4}$ in head; caudal fin widely forked, lobes long and slender, upper a little the longer, more than half longer than head, and $2\frac{2}{3}$ in body; pectoral moderate, $1\frac{1}{5}$ in head; ventrals very small, $6\frac{1}{2}$ in head. Snout $3\frac{3}{4}$ in head. Premaxillary protractile.

Color dark steel-blue or blackish above; lower parts soiled white; axil and base of pectoral within jet-black; dorsal and anal each with a narrow whitish edging; caudal black, each lobe with a narrow whitish edging within; body covered with small smooth scales, much as in *Trachinotus*. Lateral line undulate; very slightly arched anteriorly.

One specimen, 16 inches in length, from Clarion Island.

Type, No. 11996, L. S. Jr. Univ. Mus.

20. **Carangoides orthogrammus** (Jordan & Gilbert). Seven large specimens from Clarion and Socorro islands.

21. **Caranx marginatus** Gill. Two large specimens from Socorro Island.

22. **Caranx lugubris** Poey. Three large specimens from San Benedicto and Clarion islands.

Family APOGONIDÆ.

23. **Apogon retrosella** (Gill). About 30 specimens secured with dynamite at San Benito Island.

24. **Apogon atricaudus** Jordan & McGregor, new species.

Head $2\frac{1}{2}$; depth 3; D. VI–I, 9; A. II, 8; scales large, finely ctenoid, 3–26–11; eye $3\frac{1}{2}$ in head; second dorsal spine stoutest, about 2 in head; gillrakers 17, moderate. Body similar in shape to *A. retrosella*. Jaws reaching to posterior border of eye, $1\frac{5}{6}$ in head. Pectoral reaching to opposite front of anal, $1\frac{3}{5}$ in head. Color rosy, darkened with dusky points, more or less olivaceous above; head and throat verging on orange; first dorsal black; second dorsal rosy; caudal dusky, more or less flushed with rosy, other fins paler; no black spot on head or on base of caudal, there being no definite markings anywhere except the dusky red of the tail. Numerous specimens collected at San Benedicto, Socorro, and Clarion islands. Usual length 3 to 4 inches. Type, No. 5708, L. S. Jr. Univ. Mus.

Family KUHLIIDÆ.

25. **Kuhlia arge** Jordan & Bollman. Thirty-one specimens, from Clarion and Socorro islands, where it is very common.

Family SERRANIDÆ.

26. **Epinephelus labriformis** (Jenyns). Three specimens, taken at Socorro Island.
27. **Epinephelus analogus** Gill. The two specimens from Clarion Island are very dark, almost black, and scarcely spotted, except on the breast.
28. **Dermatolepis punctatus** Gill. Three specimens from Clarion and Socorro islands.
29. **Paranthias furcifer** (Cuvier & Valenciennes). San Benedicto, Socorro, and Clarion islands. Seventeen fine specimens obtained.
30. **Paralabrax clathratus** (Girard). One specimen from Todos Santos Bay.
31. **Pronotogrammus multifasciatus** Gill. One young example from Clarion Island. Head $2\frac{3}{4}$; depth $3\frac{1}{2}$; D. x, 15; A. III, 7. Snout $\frac{2}{3}$ of eye. Gill's specimen was of the same size as ours (2 inches). Ours differs from the description in having no rufous bands. Color very pale brown; upper third of body thickly sprinkled with fine black spots. In other respects this specimen agrees with the very young one on which the species was based.

Family PRIACANTHIDÆ.

32. **Priacanthus carolinus** Lesson. This species is very close to *Priacanthus cruentatus* of the West Indies, from which it is very doubtfully distinguished by the larger spine on the preopercle, which reaches the edge of the opercle and is $2\frac{1}{2}$ in eye. That of *P. cruentatus* does not reach opercle and measures 4 in eye; its edge less rough. Body a little deeper than in *P. cruentatus;* depth of the latter 3 in the length. In *P. carolinus* the depth is $2\frac{3}{5}$ in the length. In color and general appearance similar. Caudal truncate. The distinction of this species from *P. cruentatus* is very doubtful. Socorro and Clarion islands; 4 specimens.

Family LUTIANIDÆ.

33. **Evoplites viridis** (Valenciennes). Abundant at the Revillagigedo Islands, Clarion, and Socorro; 18 specimens obtained.

Family HÆMULIDÆ.

34. **Anisotremus davidsoni** (Steindachner). One specimen from Cerros Island.
35. **Anisotremus interruptus** (Gill). Three specimens from Clarion and Socorro islands.

Family KYPHOSIDÆ.

36. **Girella nigricans** (Ayres). Four specimens from San Benito Island.
37. **Kyphosus analogus** (Gill). Eight specimens from Clarion and Socorro islands.
38. **Kyphosus elegans** (Peters). Four specimens from Clarion and Socorro islands.
39. **Kyphosus lutescens** (Jordan & Gilbert). A distinct species, quite different from *Kyphosus elegans*, differing in larger body, smaller scales, lower pectorals, and especially the larger mouth and broader teeth. In all, 19 specimens were obtained. Those from Clarion Island indicate a marked dichromatism. The coloration of four typical specimens may be described as follows:

    1. Everywhere bright lemon-yellow.

    2. Dull dark-brown, almost black, slightly paler on lower half of body; a large lemon-yellow area beginning on the nape extending over the sides and front of the head; this includes the opercle, upper part of preopercle, suborbital and preorbital on right side, while on left side the color does not reach quite so far down; in front the color descends to a deep groove above the upper lip; under lip, tip of left pectoral, and tip of caudal also yellow; length, 16 inches.

3. The yellow patch extending backward to front of dorsal and below on sides only to a line passing horizontally through center of eye; no color on pectorals, and only a few small blotches on caudal and lower lip; length, 16 inches.

4. Everywhere dark-brown; scales of sides and lower parts with lighter centers, the brown being reduced to a mere edging; no yellow anywhere; length, 11 inches.

40. **Medialuna californiensis** (Steindachner). One specimen from Cerros Island.

Family SCIÆNIDÆ.

41. **Genyonemus lineatus** (Ayres). Five specimens from Ensenada, Todos Santos Bay.

Family CHÆTODONTIDÆ.

FORCIPIGER Jordan & McGregor, new genus.

Type *Chelmon longirostris* Cuvier & Valenciennes.

This genus differs from *Prognathodes* Gill in having smaller scales, about 175 in a lateral series instead of 40. *Chelmon* Cuvier is also closely related, having the same forceps-like mouth; but in the latter genus the spinous dorsal is much less developed, containing about 9 spines.

42. **Forcipiger flavissimus** Jordan & McGregor, new species.

Head $2\frac{1}{2}$; depth 2; eye $6\frac{1}{2}$ in head; D. XII–22; A. III, 17; snout $1\frac{4}{5}$ in head, its free part $2\frac{4}{5}$ in head. Body short, strongly compressed, its outline angular; anterior profile very steep, concave, extending into the forceps-like mouth. Mouth small, at tip of projected head; cleft of mouth $1\frac{1}{2}$ in eye. Scales 9–75–35; small, ctenoid, irregularly placed, smaller on head and bases of fins; rows along lateral line parallel with it only anteriorly; those below run horizontally on lower parts of body and irregularly upward and backward above; lateral line concurrent with back. Dorsal spines extremely strong; fifth spine $1\frac{3}{4}$ in head; longest soft rays $2\frac{1}{2}$ in head; caudal $2\frac{1}{6}$ in head, slightly lunate; upper lobe longer; third anal spine very long, much longer than second, $1\frac{4}{5}$ in head; pectoral $1\frac{1}{4}$ in head; ventral $1\frac{1}{2}$ in head. Color bright orange, deepest at base of dorsal; head and nape abruptly black to level of lower point of eye; below this point reddish pearly; breast and lower jaw nearly white; preorbital bones paler than cheeks, which are mottled with brownish; median region of top of head paler; pectoral slightly dusky; dorsal and anal colored like body; last rays of anal with a large black blotch, vertically oblong, its longest diameter a little greater than diameter of eye; not ocellated as in *F. longirostris;* soft rays of dorsal and anal blackish at tip, the very edge pale; caudal abruptly blackish.

This species is extremely close to *F. longirostris*, which is common in the East Indies. The American species differs, however, in the deeper body and much larger anal spot, which is almost round in the East Indian species. This species belongs to the new genus *Forcipiger*, of which *Chelmon longirostris* Cuv. & Val. may be taken as type. Four specimens from Clarion and Socorro islands; one specimen from San Benedicto Island. Length, from 5 to 7 inches. Type No. 5709, L. S. Jr. Univ. Mus., Clarion Island.

43. **Chætodon nigrirostris** (Gill). Six specimens from San Benedicto, Socorro, and Clarion islands; largest about 6 inches long.

44. **Holacanthus clarionensis** (Gilbert). Eighteen specimens from Clarion and Socorro islands. A very young example from Clarion Island may be thus described: D. XIV, 17; A. III, 18; head $4\frac{1}{2}$ in total length; depth $2\frac{1}{3}$; pectoral equal to head; interorbital space equal to eye; eye 3 in head. Color in alcohol, very pale yellow; two parallel dark-brown bands passing vertically from near lower edge of preopercle to occiput, one on each side of eye,

the two anterior bands joining on top of head, forming an inverted ʌ, above which is a dark-brown spot; on posterior half of body, extending from dorsal to anal, but not on these fins, are finer bands of very dark brown; between each two bands is a parallel row of spots; these are also five in number; posterior half of body dark; caudal and peduncle abruptly light; dorsal and anal plumbeous, each with an edging of black, which becomes wider on posterior rays of each fin; traces of bright orange near anterior part of dorsal.

Family ZANCLIDÆ.

45. Zanclus cornutus (Linnæus). Twelve fine specimens from Clarion and Socorro islands.

Family TEUTHIDIDÆ.

46. Teuthis triostegus (Linnæus). Abundant at Clarion and Socorro islands, where 18 specimens were taken.

47. Teuthis aliala (Quoy & Gaimard). Head $3\frac{2}{3}$; depth $1\frac{3}{4}$ to $1\frac{4}{5}$; eye $3\frac{1}{2}$; maxillary 6 in head; D. IX, 30; A. III, 26; from eye to corner of mouth $1\frac{1}{4}$ in head; gill-opening $1\frac{1}{5}$ in head; opercle short and obliquely set, $4\frac{1}{3}$ in head; humeral bone striate. Body ovate, strongly compressed, closely covered with small rough scales, which become shagreen-like on head; lateral line present but obscure; anterior profile strongly convex above and before the eye, thence somewhat concave and nearly vertical to the small projecting mouth. Teeth broad, digitate, each with 4 or 5 claw-like serræ at tip; lower teeth with serræ much smaller, forming notches. Jaws very short, about equal, about ten incisors in each. Anterior nostril moderate, close to posterior, which is much smaller. Dorsal and anal low, continuous, rounded behind; longest dorsal ray near end of fin, $2\frac{1}{5}$ in head; longest anal ray 2 in head; caudal lunate, upper and lower angles produced but acuminate and short; middle rays $1\frac{1}{3}$ in head, the outer 1 in head; caudal spine very strong, $2\frac{1}{5}$ in head, attached near its posterior end; the short, sharp posterior end free, the long knife-like anterior portion slipping into a groove in the flesh; pectoral long, $\frac{1}{4}$ longer than head; ventrals $1\frac{1}{6}$ in head.

Color dark purplish-brown, almost black; a pale yellowish or flesh-colored crescentic area under eye; a ring of pearly whitish around mouth, not quite continuous above; a pale streak along dorsal fin, widening behind into a pale orange patch, occupying two-thirds of height of last ray; base of last ray dusky; anal marked in the same way as the soft dorsal; a very narrow pale edge to soft parts of dorsal and anal; pectoral black; caudal abruptly pale at end of black caudal peduncle, with a curved dark streak parallel with edge of fin and nearly the diameter of the eye behind it; behind this a diffuse yellow area parallel with the dark streak; fin behind with a narrow pale edging; flap of opercle narrowly pale.

Abundant at Clarion and Socorro islands, where 12 specimens were taken. We can not distinguish our specimens from descriptions and figures of *Teuthis aliala* (*Acanthurus glaucopareius*) of the East Indies.

48. Xesurus punctatus (Gill). Two adults from Socorro Island.

49. Xesurus clarionis (Gilbert & Starks). Twelve specimens from Clarion and Socorro islands.

Family BALISTIDÆ.

50. Pachynathus capistratus (Shaw). Six specimens from Clarion and Socorro islands.

51. Melichthys bispinosus Gilbert. Nine specimens from Socorro and Clarion islands.

52. Xanthichthys mento (Jordan & Gilbert). Seventeen specimens from Clarion and Socorro islands.

Family MONACANTHIDÆ.

53. **Cantherines carolæ** Jordan & McGregor, new species. (Plate 6.)

Head $3\frac{1}{10}$; depth 2; D. I–38; A. 34; eye $5\frac{1}{2}$. Body elliptical, compressed; anterior profile somewhat concave, oblique; mouth small; teeth large, white, and irregular. Gill-opening somewhat in front of pectoral, its length $3\frac{1}{2}$ in head; dorsal spine very stout and straight; everywhere rough, but without distinct barbs; $1\frac{1}{2}$ in head; dorsal rays 2 in head; anal ray 2 in head; caudal short and rounded, $1\frac{3}{5}$ in head; pectoral $2\frac{1}{2}$ in head. Pelvic bone with ventral spine firmly attached, with about 10 radiating spinules; ventral flap little developed; caudal peduncle with four strong, bluntish spines, turned forward and arrayed in two pairs, one above and one below the middle line. Color dull grayish-olive; head finely speckled with darker; fins all pale; lips whitish. Length 11 inches; two specimens from Socorro Island.

The species is named for Mrs. Charlotte C. McGregor.

54. **Ceratacanthus scriptus** (Osbeck). Thirteen specimens from Clarion and Socorro islands. A specimen has been recently sent us from the Venados Islands at Mazatlan, by Dr. George Warren Rogers.

Family TETRAODONTIDÆ.

55. **Ovoides setosus** (Rosa Smith). Very abundant about Socorro and Clarion islands; 48 fine specimens taken; mostly in shallow water during low tide at Clarion Island. These vary in color from pure lemon-yellow to indigo-blue and dark brown, with round white spots. There are also various intergradations, as yellow blotched with blue, the singular variations in coloration being parallel with those of *Kyphosus lutescens*.

Family DIODONTIDÆ.

56. **Diodon hystrix** Linnæus. Five specimens from Clarion and Socorro islands.

Family EMBIOTOCIDÆ.

57. **Abeona minima** (Gibbons). One specimen. Todos Santos Bay.

58. **Brachyistius frenatus** Gill. Five specimens from Guadalupe Island, 4 to 5 inches in length. These are somewhat deeper than the typical form from California, but we do not think them specifically distinct. Also taken at Todos Santos Islands. Head 3; depth 2; D. VIII–13; A. III, 22; scales 44; eye in head 3; pectoral in head $1\frac{1}{3}$; ventral $1\frac{1}{2}$; second anal spine $4\frac{1}{2}$; middle caudal rays $2\frac{1}{2}$. Body short and compressed; back elevated; head depressed above snout, which sharply projects; mouth, small, projecting, maxillary not reaching to opposite eye. Gillrakers 23, slender. Color olivaceous above with darker blotches on each scale, forming lengthwise stripes; lower parts tinged with coppery; a large moon-shaped black spot in axil of pectoral, nearly as large as eye, but not so wide; fins pale, lower ones, especially caudal, flushed with orange.

59. **Embiotoca jacksoni** Agassiz. Specimens taken at Todos Santos, San Benito, Cerros, and Guadalupe islands.

60. **Tæniotoca lateralis** (Agassiz). Two specimens from San Benito Islands.

Family POMACENTRIDÆ.

AZURINA Jordan & McGregor, new genus.

This genus is closely allied to *Chromis*, from which it differs in the long and slender body, the low vertical fins, the very deeply forked tail, the pointed snout, and especially in the continuous lateral line which extends much beyond the dorsal fin, and is wanting on but two or three scales.

61. **Azurina hirundo** Jordan & McGregor, new species. (Plate 7.)

Head 4 in length; depth $3\frac{1}{3}$; D. XII, 11; A. II, 11; scales 34; maxillary 3 in head; eye $4\frac{1}{4}$; pectoral 1; ventral $1\frac{1}{2}$; longest dorsal spine $3\frac{3}{5}$; longest soft ray $3\frac{3}{4}$; second anal spine $3\frac{1}{2}$; longest anal ray 3; caudal lobes $1\frac{1}{3}$; middle caudal rays 4. Body elongate, elliptical, slender, and symmetrical, moderately compressed; snout acute; profile slightly depressed above. Eye moderate, larger than in related species; maxillary reaching to below front of eye. Teeth conical, rather few and small, in narrow bands or almost a single series. Preorbital very narrow, about one-half eye; suborbital hidden by scales. Preopercle narrow, largely free, its edge slightly crenulate; gillrakers 36, long and slender; head covered with small scales except throat and tip of snout; those on body large and ctenoid, lateral line strongly curved, continuous, extending downward along the tail, wanting on two or three scales only. Caudal deeply forked. Color deep steel-blue above, slightly paler below, with a tinge of orange at throat; pectoral light yellow, dusky at base; other fins black, each with a narrow whitish edge. West coast of Mexico. Three specimens from Guadalupe Island, each $6\frac{1}{2}$ inches long. A beautiful fish with a symmetrical outline, unusual in this family. Type No. 5706, L. S. Jr. Univ. Museum.

62. **Chromis punctipinnis** (Cooper). Many young from Todos Santos Island; adult examples from Guadalupe, Cerros, and San Benedicto Islands.

63. **Abudefduf saxatilis** (Linnæus). Abundant in the tide pools at Clarion Island; 11 specimens taken.

64. **Eupomacentrus leucorus** (Gilbert). Socorro Island, 6 specimens; San Benedicto Island, 6 specimens; Clarion Island, 4 specimens; a strongly marked species.

65. **Eupomacentrus rectifrænum** (Gill). Six specimens from Clarion and Socorro islands.

66. **Eupomacentrus flavilatus** (Gill). Head $3\frac{1}{3}$; depth 2; D. XII, 15; A. II, 13; scales 29; eye in head $3\frac{1}{2}$; pectoral in head $1\frac{1}{6}$; ventral in head 1; longest dorsal spine 2; second anal spine 2; body deep, robust; anterior profile more or less convex and broad; general appearance of *E. rectrifrænum*, from which this seems to differ only in color. No blue spots, even in specimens 3 to 5 inches long; posterior part of body, especially pectoral and caudal, light yellow; rest of body paler than in *E. rectrifrænum*, but color variable; ventrals black; dorsal and anal dusky, more or less pale posteriorly; pectoral with a very distinct black spot at base of upper rays. The latter species has the tail and caudal as dark as other fins, which is not the case in *E. flavilatus*. Twelve specimens from Socorro Island, two from Clarion Island, and one from San Benedicto Island.

67. **Hypsypops rubicundus** (Girard). One young example, 4 inches long, from Guadalupe Island agrees in the distribution of blue spots with Mrs. Eigenmann's description. Eight specimens of different sizes from Todos Santos and Cerros islands.

68. **Microspathodon dorsalis** (Gill).

Microspathodon cinereus Gilbert; adult;

Microspathodon azurissimus Jordan & Culver; partly grown.

Ten very fine specimens from Clarion and Socorro islands.

69. **Microspathodon bairdii** (Gill). Head 3; depth $1\frac{5}{8}$; D. XII, 16; A. II, 14; scales 3–29–10. Body short, compressed, elongated; nape abruptly produced behind and above a depression which lies above eye, nape thus projecting forward in a fleshy crest. Anterior profile steep with fleshy corrugations separated by depressions. Tip of snout above premaxillary enlarged to a fleshy pad, under which the jaw slips, separated from preorbital and top of head by a deep crease, deeper in larger specimens. Nostril midway between eye and crest, its size much larger than in *M. dorsalis*, being $\frac{1}{4}$ diameter of eye. In *M. dorsalis* of same size the nostril is reduced to a small pore, about

$\frac{1}{3}$ of eye. Preorbital lower than in *M. dorsalis*, its height $2\frac{2}{7}$ in head in adult; in *M. dorsalis* of same size the preorbital is $2\frac{1}{8}$ in head. Teeth small, truncate, movable, about as in *M. dorsalis;* lower jaw shorter; width of mouth 2 in head; 4 or 5 rows of scales on cheek. Caudal peduncle short and deep, length $2\frac{1}{3}$ in head, its depth 2 in head. Dorsal elevated but not falcate, simply angular, its longest ray $1\frac{1}{3}$ in head; anal similar, its longest ray $1\frac{1}{2}$ in head; caudal lunate, its lobes not produced, the upper longer, $1\frac{1}{6}$ in head; pectoral $1\frac{1}{5}$ in head; ventral $1\frac{1}{8}$ in head.

Color uniform deep blue-black without paler margins to fins, except very narrow line on upper ray of pectoral and upper lobe of caudal; no spots.

This species is well separated from *M. dorsalis*, differing in the much larger nostril, fleshy hump at nape, in lower preorbital, and in the uneven slope of profile, as well as the absence of falcate tips to fins. The very small specimens which have been named *Microspathodon bairdii* seem to be the young of this species, having the large nostril and the nonfalcate fins. The bright orange markings seem to disappear with advanced age.

One adult from San Benito Island; three adults from Socorro Island.

Family LABRIDÆ.

70. Harpe diplotænia Gill. Thirteen large specimens from Socorro and Clarion islands.

71. Pimelometopon pulcher (Ayres). One specimen from Todos Santos Bay and one from Guadalupe Island.

72. Iridio semicinctus (Ayres). Several specimens taken at Cerros Island; one from Todos Santos Bay.

73. Julidio notospilus (Günther). A number of young, half an inch long, from Clarion Island.

74. Oxyjulis californicus (Günther). Specimens from Guadalupe Island and San Geronimo Island.

75. Thalassoma grammaticum Gilbert. Clarion Island. Numerous specimens.

Family MALACANTHIDÆ.

76. Caulolatilus princeps (Jenyns). Two specimens from San Martin Island.

Family CIRRHITIDÆ.

77. Cirrhites rivulatus Valenciennes. Four fine specimens from Clarion and Socorro islands.

Family SCORPÆNIDÆ.

78. Sebastodes flavidus (Ayres). One young specimen, 5 inches long, from Todos Santos Island.

79. Sebastodes chrysomelas (Jordan & Gilbert). One specimen from Todos Santos Bay.

80. Sebastopsis xyris Jordan & Gilbert. Head $2\frac{2}{3}$; depth $3\frac{1}{2}$; D. XII-I, 10; A. III, 5; scales 48; maxillary in head $1\frac{4}{5}$; eye $3\frac{1}{2}$; pectoral about 1; longest dorsal spine $2\frac{2}{3}$; second anal spine $1\frac{2}{3}$; ventral $1\frac{1}{2}$; middle caudal ray about 2. Body moderately elongate; head rather sharp; jaws equal; interorbital space concave; top of head scaly and without occipital depression; nasal spines sharp with a fleshy flap nearly as long as pupil. Spines above eye each with a similar fleshy flap. Preorbital, superorbital, postorbital, and tympanic spines present, each sharp and high. Occipital and nuchal spines also well developed; a small temporal spine; a small spine under the eye on the sharp stay; a spine at end of stay in front of the preopercular spine; the last has a small spine at its base; two sharp spines below opercular spine. Cheeks and opercle covered with ctenoid and imbricated scales without flaps; body scales ctenoid and closely imbricated, without flaps.

Gillrakers very short and slender. Breast covered with imbricated cycloid scales. Villiform teeth on jaws and vomer, none on palatines. Dorsal thin and moderately deeply notched; caudal rounded; third anal spine greater than second; pectoral with upper rays branched; lower or simple rays thickened and the upper of them longer than any of the branched rays.

Color light-olive, irregularly banded and blotched with darker; flushed with cherry-red; subopercle with large black blotch somewhat ocellated. Head blotched with olive and paler. Jaws and throat largely orange. Dorsal mottled with blood-red, orange, and whitish. Pale-yellowish bar across soft dorsal, then a blackish streak; rest of fin white, tipped with black; caudal largely bright-scarlet, black toward tip. Anal largely scarlet, mottled with black; pectoral yellowish, barred with white and black, lower part of fin washed with scarlet; ventral light yellow, with a few black spots on posterior half, and scarlet spots on anterior portion. The most definite marks are a dark bar from soft dorsal to base of anal, everywhere washed with scarlet, and black spot on the subopercle.

Three specimens collected at Socorro Island, 3½, 2¼, and 2 inches, respectively.

Family COTTIDÆ.

81. **Clinocottus analis** (Girard). Todos Santos and San Martin islands.

Family GOBIIDÆ.

82. **Gobius soporator** Cuvier & Valenciennes. Numerous specimens taken in the tide pools at Socorro and Clarion islands.

83. **Gobius zebra** Gilbert. Two specimens from Todos Santos and Clarion islands; larger one 1¾ inches. The colors in life—blue stripes on a crimson ground—were very beautiful.

Family GOBIESOCIDÆ.

84. **Gobiesox adustus** Jordan & Gilbert. Two specimens, each an inch long, in tide pools at Clarion Island.

Family BLENNIIDÆ.

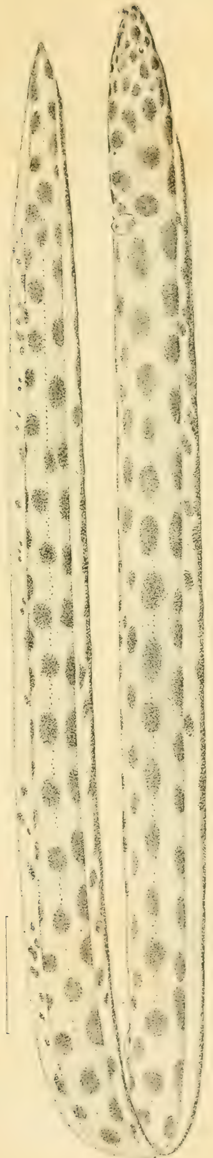
85. **Heterostichus rostratus** Girard. Interorbital ¼ less than orbit. One specimen, 7 inches long, from Guadalupe Island.

86. **Gibbonsia elegans** (Cooper). One specimen from San Martin Island.

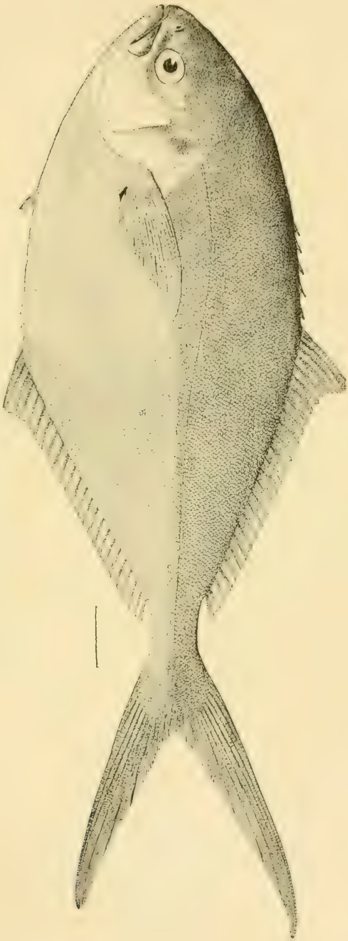
87. **Entomacrodus chiostictus** (Jordan & Gilbert). Specimens taken in tide pools at Clarion and Socorro islands.

Family PLEURONECTIDÆ.

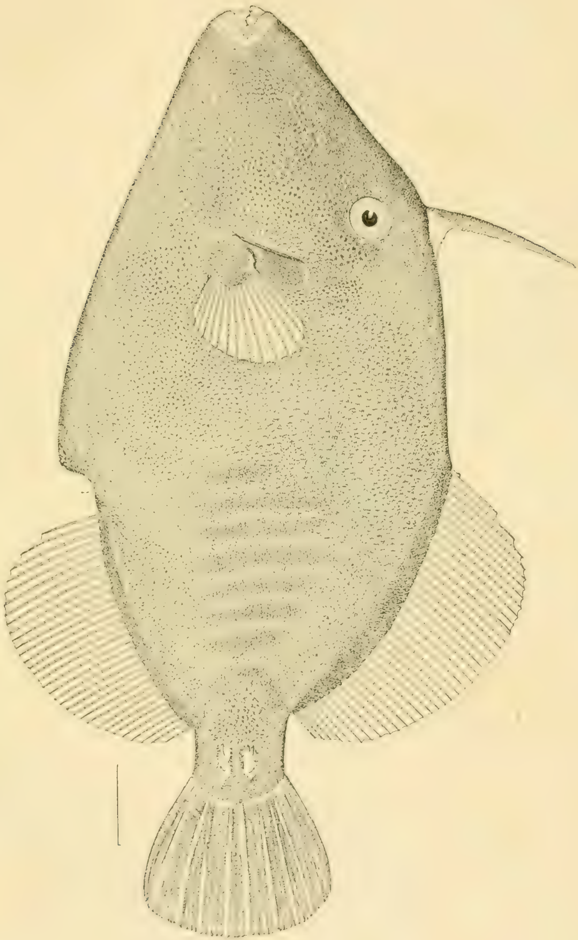
88. **Platophrys leopardinus** (Günther). Three specimens taken at Clarion Island. Length of each about 3 inches.



MYRICHTHYS PANTOSTIGMIUS Jordan & McGregor. New species.

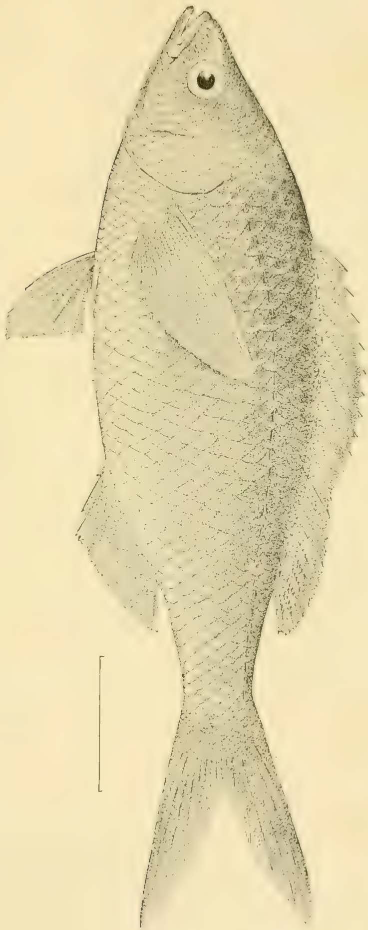


ZALOCYS STILBE Jordan & McGregor. New genus and new species.



CANTHERINES CAROLÆ Jordan & McGregor. New species.

PLATE 7.



AZURINA HIRUNDO Jordan & McGregor. New genus and new species.

REPORT

ON

INVESTIGATIONS BY THE UNITED STATES FISH COMMISSION IN MISSISSIPPI, LOUISIANA, AND TEXAS, IN 1897.

By Barton Warren Evermann, Ph. D.,
Ichthyologist of the United States Fish Commission.

REPORT ON INVESTIGATIONS BY THE U. S. FISH COMMISSION IN MISSISSIPPI, LOUISIANA, AND TEXAS, IN 1897.

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INTRODUCTION.

In the present paper are embodied reports upon three distinct investigations, viz:

1. An examination of the waters in southwestern Mississippi in the vicinity of the mouths of Pearl River, for the purpose of determining their general character, what fishes they already contain, and whether additional species may be advantageously introduced into them. This investigation was made at the instance of Hon. Robert C. Davey, Representative in Congress from the second district of Louisiana, Hon. A. Baldwin, of New Orleans, and other gentlemen of that city, who take an interest in keeping up the supply of game and food-fishes of that region.

2. An investigation of the catfish industry of the Atchafalaya River, Louisiana. Representations had been made to the Commission by the fishing firms of Morgan City, through Hon. Robert F. Broussard, Representative in Congress from the third district of Louisiana, that the catch of catfish had greatly decreased within the last few years. It was requested that an investigation be made as to the fact and cause of the decrease, and that recommendations be made as to the remedy.

3. Upon the recommendation of Hon. S. B. Cooper, Representative in Congress from the second district of Texas, an examination was made of the Sabine and Neches rivers with reference to their fitness for shad.

These various investigations were carried on under the immediate direction of Professor Evermann, who was assisted in the field work by Mr. Fred. M. Chamberlain and Mr. H. R. Center, both of the division of scientific inquiry of the U. S. Fish Commission. The party left Washington April 13, 1897, arriving at New Orleans the next day. On the 15th they went to Baldwin Lodge, Mississippi, at the mouth of Pearl River, where investigations were carried on by the entire party until April 18, and by Messrs. Chamberlain and Center for one day longer. On the 19th Professor Evermann went to Morgan City, and at once went on board the fishing tug *Shamrock* for a trip through those portions of the Atchafalaya River and its connecting lakes and bayous

in which catfish fishing is carried on, returning to Morgan City on the 21st, where he remained until the 24th. Messrs. Chamberlain and Center reached Morgan City on April 20, and the next four days were devoted to examining the fish which were being prepared for shipment in the three fish-houses of that place. Collections were also made in the waters about Morgan City.

On April 24 Professor Evermann went to New Iberia, at Mr. Broussard's request, to examine Lakes Tasse and Peigneur, in that vicinity. Mr. Chamberlain joined him on the evening of the 25th, when both proceeded to Beaumont, Tex., where they spent one day, and then proceeded to Lufkin, Tex. After spending one day at Lufkin, examining the Neches and Angelina rivers, they went to Logansport, where the Sabine River was examined April 29. From Logansport Mr. Chamberlain went to Melville, La., where he spent four days examining the catfish handled there, while Professor Evermann went to Athens, Ga., to examine a site for a proposed fish-hatchery at that place. Mr. Center remained at Morgan City compiling the statistics of the catfish fishery at that place until April 27, when he returned to Washington. Professor Evermann returned to Washington May 4. On May 7, Mr. Chamberlain completed his inquiries at Melville and the investigation was brought to a close.

During the conduct of these investigations we were the recipients of numerous courtesies from various gentlemen, who by their kindly and intelligent interest contributed in no small degree to the successful completion of the work. Thanks are especially due Hon. Robert F. Broussard, Hon. A. Baldwin, and Mr. Edward G. Schlieder, of New Orleans; Messrs. Edgar Bass, John Dalton, and Manuel Coguenhem, of Morgan City, and Mr. Charles Larson, of Bayou Chêne, La.

SOUTHWESTERN MISSISSIPPI.

The object of the investigations in this region was to determine the general character of the waters, the species of fishes inhabiting them, their abundance and habits, and the desirability of introducing other species of food or game fishes.

Baldwin Lodge, on the Louisville and Nashville Railroad, 39 miles northeast of New Orleans, was the center of our operations. This place is within a short distance of the mouth of the Pearl River, where it empties into Lake Borgne. The surrounding country is, in the main, low, level, and subject to overflow; much of it is tide marshes and bayous, narrow channels or creeks; ponds and lakes are numerous. Bayou Isle aux Pois (or Campbell Bayou) runs immediately in the rear of Baldwin Lodge, opening into Pearl River on the west and into Grand Plains Bayou at the other end. It is about 90 feet wide and 12 feet deep. Its shores, except at Baldwin Lodge, are low and marshy, and overgrown with marsh grass and a few bushes. Grand Plains Bayou connects with this bayou to the eastward and extends several miles to the north and east. It is of the same general character and of about

the same size. Several other bayous connect with it, one of them being known as Lagoon Bayou, which is the outlet of two small lagoons. Its shores and those of the upper portion of Grand Plains Bayou are higher and more liberally supplied with water willows and other woody vegetation. Near its mouth Pearl River divides into several branches, known as West Pearl River, Middle Pearl River, etc. Opening into West Pearl River is Black Bayou, which is much frequented by anglers. It is about 40 feet wide, 5 to 15 feet deep, and several miles long. Its shores are low and marshy and covered with a dense growth of marsh grass. In the water was a rank growth of water vegetation, consisting of *Ranunculus*, *Myriophyllum*, *Anacharis*, *Potamogeton*, *Nymphæa*, and *Nuphar*, both of the latter in bloom.

Another bayou opening into Pearl River is known as Mulatto Bayou, which flows through the Sea Glen plantation, several miles north of Baldwin Lodge. The land along the greater length of this bayou is considerably higher than along the other bayous mentioned. At Sea Glen the ground is 5 to 15 feet above the water, and is covered with groves of magnificent pecans and a few magnolias. Many of these trees are of immense size, and the oaks are rendered unusually beautiful by the great mats of *Polypodium* growing upon their trunks and larger branches; and the masses of *Tillandsia usneoides*, or long moss, hanging in long, graceful festoons, form a rich drapery to the branches.

Pearl River has several outlets or mouths, all opening finally into Lake Borgne. This lake is approximately 25 miles long by 10 to 12 miles wide, the greatest length extending in a northeast and southwest direction. It is a very shallow body of water, the average depth probably not exceeding 8 feet. South of Baldwin Lodge a depth of 18 to 20 feet is found, but it rarely exceeds 9 feet.

The country surrounding Lake Borgne consists almost entirely of low tide marshes, with rank growths of marsh vegetation, but scarcely any bushes or trees, and is intersected and cut up by numerous narrow channels or bayous. Our visit to this region was at the time of the great flood of the Lower Mississippi, and the basin of the Pearl River was also somewhat affected. The water in all the bayous visited was deeper than usual, owing to backwater from Pearl River. Southern winds continuing for several days frequently have the same effect.

At this time the water in all these bayous was practically fresh, and even Lake Borgne was not strongly brackish. In the late summer and fall, however, the water is much shallower. Ordinarily it begins to grow brackish late in April or May, and gradually increases until the fall rains set in, when it becomes gradually less brackish, and during a portion of the winter and early spring it is comparatively fresh. At this time various fresh-water species of fishes extend their range even down to Lake Borgne and its connecting bayous. Among them are large-mouthed black bass, catfish, warmouth or "goggle-eye" perch, gaspergou, buffalo, gar, and sunfish. During the drier season the opposite result is noticed. The fresh-water species are driven farther

toward the interior, while the lower portions of the bayous are invaded by many species of salt-water and brackish-water fishes, such as red drum, sheepshead, mullet, flounder, croaker, needlefish, black drum, speckled sea-trout, porpoise, dogfish, pipefish, and the like.

That portion of Mulatto Bayou lying above Sea Glen usually remains practically fresh throughout the year. A short distance above Sea Glen such fresh-water species as large-mouthed black bass, "goggle-eye," and crappie may be found at any time. At the time of our visit the fresh-water species mentioned above were found in all of the bayous named. The brackish-water species were not common anywhere, and were not found at all at any considerable distance from Lake Borgne. Even in that lake they were very rare. The water in all the bayous was dark in color on account of mud and other impurities brought down by Pearl River. The temperature of the water at the surface was usually a few degrees warmer than that of the air. In Bayou Isle aux Pois, when the air was 64° the surface of the water was 67° to 68°, and at the bottom (10 feet) it was 65°. The surface in Pearl River at 11 a. m. was 68°, that of Black Bayou was 70°. On April 17 the surface temperature of Lake Borgne was 69° when the air was 62.5°.

Considerable collecting was done in the several bayous and specimens of most of the fishes to be found there at that season were secured. These were, of course, principally fresh-water species. The anglers who resort to this region during the spring depend upon these fresh-water species, or else go farther out, where they can get sheepshead, red drum, and other salt-water species. During summer and fall only the salt-water species can be obtained, except in the upper portions of the bayous. Most of the fresh-water fishes seem to be quite abundant. The crappie (*Pomoxis annularis*), however, seems far scarcer than it should be under the favorable environment which obtains in the upper portion of Mulatto Bayou and neighboring bayous, and it is recommended that a large plant of that species be made in those waters.

ATCHAFALAYA RIVER, LOUISIANA.

The investigations on this river were for the purpose of determining the character and extent of the catfish fishery, the fact and cause or causes of the alleged decrease in the catch during the last three or four years, and to determine what remedial measures, if any, should be recommended.

As this business centers chiefly at Morgan City, most of our investigations were made at that point. We were able at this place to examine the fish brought in by the fishing-tugs and to obtain the statistics of the fishery. Mr. Chamberlain spent several days at Melville making similar inquiries. A three days' trip which Professor Evermann took on one of the tugboats, while on its regular trip collecting the catches of the individual fishermen, afforded an excellent opportunity to observe the method of the fishery. The Atchafalaya River

is, in some respects, a peculiar stream. It has its sources in Avoyelles and Pointe Coupee parishes, near where the Red River joins the Mississippi, and is at all seasons more or less connected with both of those rivers by a number of anastomosing channels and bayous. The Atchafalaya River is, in fact as well as historically, one of the mouths of the Mississippi River, and during the floods which come periodically to that region a vast amount of the surplus water of the Mississippi and Red rivers is carried to the Gulf by the Atchafalaya.

The distance from the sources of the Atchafalaya River in a straight line to its mouth (about 90 miles southwest of New Orleans) is about 125 miles. The river is, however, very sinuous in its course, and its actual length is therefore many miles greater. The general course is a few degrees east of south, and forms a narrow angle with that of the Mississippi. The country through which the river flows is very low and level, often lower than the river itself, and made up for the most part of cypress swamps. The highest land is in many places the immediate banks of the river. These swamps are reticulated and intersected by a very complex and intricate network of bayous and lakes, all comparatively shallow except during the time of floods, when they become passable for the pirogue of the fisherman and the swamper, and the tugboats of the fish companies at Morgan City and Melville. During excessive floods, such as that of April and May, 1897, practically the entire country north of Morgan City is inundated. To provide against such conditions many of the natives live in house-boats. All of the residences built upon the ground are two stories high, and the people hold themselves in readiness to vacate the ground floor and betake themselves and remove their household goods to the second story whenever the flood comes. Every family possesses one or more boats, which are an absolute essential in that country. Bee-culture is of some importance in this part of Louisiana, and it was noticed that the beehives in all the apiaries seen were placed upon scaffolding or posts which raised them several feet above the surface of the ground. Such live-stock as chickens, pigs, and goats are also protected from the flood by placing them upon similar platforms. Ducks and geese are the only possessions which do not cause some trouble or anxiety during the times of flood.

The majority of the people of this region are either swampers or fishermen, or both. The cutting of the cypress timber for commercial purposes and getting the logs out into the river, so that they may be gotten to the mills, is called "swamping," and those who engage in it are termed "swampers." The cypress trees are cut into logs, which are dragged over the ground or pulled through the water to the nearest float road, by means of which it is easy to float them to the river, in which they may be rafted or otherwise taken to the sawmills. A "float road" is made by cutting away all the trees and bushes in various places through the swamps where roads are desired, and when the flood comes these become open waterways, through which the

pirogue finds easy passage. These float roads also have an important relation to the fishing industry, as will appear later on in this report.

There are four species of commercial catfishes handled by the firms at Morgan City and Melville, viz: The blue cat or poisson bleu (*Ictalurus furcatus*), the yellow cat or goujon (*Leptops olivaris*), the eel cat (*Ictalurus anguilla*), and the spotted cat (*Ictalurus punctatus*). The blue cat and the goujon are by far the most important species, and probably constitute 98 per cent of the entire catch.

The methods employed in this industry are very interesting. Ordinarily the fishing season extends from September to May, little being done during the summer months. In some cases, however, the fishing has continued throughout the year. Practically all the fishing is done with "trot lines" and "brush lines," though a few catfish are sometimes taken in hoop nets, which are set primarily for buffalo. The standard length of a single trot line is 25 feet, which equals 1 bale of line, but a number of lines are always tied together. There is no definite length of the string, this depending upon the width and character of the body of water in which it is set. The length may vary from a few rods to over a mile. The longest line of which we heard was one 12 miles long, which has been used in Grand Lake. The twine used is usually what is known as Woodbury 96 or Banner Mills 96, which is somewhat smaller than an ordinary lead pencil. The snoods are usually 18 inches long, and they are placed 3 feet apart. The hooks are fastened on by a double staging and various sizes are used, such as Virginia, Limerick (Nos. 6, 7, 8, and 9 0), and Millwood (Nos. 5 and 6.)

All river fishing during the fall and winter is done on the bottom, while all lake fishing is at the surface. During the spring, when the country is flooded, the fish betake themselves to the woods, and the fishing is then carried on chiefly along the edges of the float roads. The old tackle, which had been previously used in the river and lakes, is now cut up into short lengths and tied, as single lines, called brush lines, to the limbs of trees in such a way as to allow the single hook to hang about 6 inches under the water. Each fisherman ties his lines to trees along the edges of the float roads if he can find such territory not already preempted by some one else. The fishing is thought to be better in such places; besides, it is easier to visit the lines when so located. Any fisherman who is unable to find unoccupied space along the float roads selects the best places he can find at various points around through the woods. In order that he may readily find his lines when he wishes to visit them, the limbs to which they are tied are marked with a white rag or the tree is blazed.

The different kinds of bait used are classed as "live bait" or "cut bait." The live bait consists chiefly of "shad" (*Dorosoma cepedianum exile*, *Hiodon alosoides*, and *Signalosa atchafalayæ*), perch, and crawfish. The "shad" are regarded as the best bait, and 100 shad are said to be worth 200 or 300 crawfish. The crawfish will live on the hook three or four days, while the shad will live only a day or two, but the shad

is a more tempting bait. Cut bait consists of larger examples of these and other fishes cut up into the proper size. Eels are said to make an excellent cut bait, but they are very scarce. Live bait is most used from September to November, inclusive, November being the best month. It is preferred to cut bait at any time, but can not be obtained in quantity except in the fall. Live bait is used, however, whenever it can be gotten, and occasionally a fisherman is fortunate enough to secure good supplies during the spring fishing.

These fish are influenced in their movements by the temperature of the water. During the winter they come farther down the river where the water is warmest, and in the summer they run farther upstream or retire to the deeper waters.

The goujon is said to be most abundant from September to November, or until the fall floods begin, when it gradually disappears. This is the best season for catching it, although a few may be found at any season. The goujon is most easily and usually taken with live bait. It is by no means a handsome fish, but its great size, the excellence of its flesh, and its superior keeping qualities render it a very important food-fish. It rarely reaches a weight of 100 pounds: but examples of 50 to 60 pounds weight are said to be not at all unusual. The largest individual seen by us was a ripe female 41 inches long and weighing 48 pounds. It dressed 27 pounds. One 38 inches long weighed 37 pounds, and another 37 inches long weighed 36½ pounds. The goujon is more voracious than the blue cat, and large individuals are apt to feed on smaller examples of the latter when confined in the same live-box. To prevent this, it is said that the fishermen sometimes sew up with wire the mouth of the very large goujon.

The blue cat has the same general habits as the goujon, but the best fishing for this species is said to be during the high water in the spring. Then the fish leave the river, lakes, and bayous and take to the woods. Good "woods or "swamp" fishing is sometimes had as early as March. The impression among the fishermen is that the fish run out over the flooded districts on account of the more abundant food supply to be found there. This consists chiefly of crawfish inhabiting the shallow pools and ponds made accessible to the catfish through the agency of the floods.

The maximum size of the blue cat is about the same as that of the goujon. The largest of which we heard weighed 100 pounds. The largest seen by us was a ripe female weighing 35 pounds. A spent female 31 inches long weighed 22 pounds and dressed 13 pounds. Another spent female 30 inches long weighed 17 pounds. It is claimed that large fish were far more numerous a few years ago than now.

The eel cat (*Ictalurus anguilla*) is comparatively rare, and not until these investigations was it discovered to be a distinct species. During the several days spent at Morgan City and Melville not more than 35 or 40 examples of this species were seen. It does not attain a greater length than 18 or 20 inches nor a greater weight than 8 pounds. The

average weight of those seen was under 5 pounds. The habits of the species do not seem to differ from those of the blue cat. They are said to be taken chiefly in the spring and in the flooded districts.

The last and least important of the four species of commercial catfishes found in the Atchafalaya River is the spotted cat (*Ictalurus punctatus*). Only three or four were seen at Morgan City during our visit, and the fishermen report that it is rarely taken. The few seen did not exceed 18 inches in length.

Table showing size, sex, and spawning condition of blue catfish examined at Morgan City, La., April 22–24, 1897.

Length.	Weight, pounds.	Sex.	Spawning condition.	Length.	Weight, pounds.	Sex.	Spawning condition.
14 inches		(?)	Immature?	21½ inches		Female	Spent.
16 inches		Female	Spent.	22 inches		Female	Do.
13½ inches		Male	Immature.	13½ inches		Female	Do.
15 inches		(?)	Immature?	16 inches		Male	Do.
13 inches		(?)	Immature?	13 inches		Female	Do.
14½ inches		Male	Immature.	20 inches		Female	Not nearly ripe.
16 inches		Male	Do.				
14 inches		Male	Do.	20 inches		Male	Ripe.
17 inches		(?)	Spent?	11½ inches		Male	Spent.
16½ inches		Male	Immature.	13½ inches		Female	Do.
16 inches		Female?	Immature?	12 inches		Female	Do.
14½ inches		Male	Immature.	16 inches		Female	Do.
15 inches		Male	Do.	16 inches		Female	Do.
16 inches		Male	Do.	18½ inches		Female	Do.
14½ inches		(?)	Immature?	19½ inches		Female	Ripe.
16 inches		Male	Immature?	13 inches		Male	Spent.
15½ inches		(?)	Immature?	14 inches		Female	Slightly developed.
21½ inches		Male	Spent.				
20 inches		Female	Do.	19 inches		Male	Spent.
19 inches		Female	Large roe.	15½ inches		Female	Do.
14 inches		(?)	Immature?	18 inches		Female	Do.
19 inches		(?)	Immature.	14½ inches		Male	Slightly developed.
14 inches		(?)	Do.				
20 inches		Female	Ripe.	14 inches		Male	Spent.
23 inches		Female	Spent.	14 inches		Male	Do.
16 inches		Female	Ripe.	14½ inches		Female	Do.
12 inches		(?)	(?)	16 inches		Male	Do.
10 inches		Male	Immature.	10 inches		Male?	Spent?
13 inches		(?)	Spent.	13 inches		Male?	Spent?
13 inches		Male	Do.	19 inches		Male	Spent.
17½ inches		Female	Do.	27½ inches		Female	Ripe.
14½ inches		Female?	Do.	10½ inches		Female?	Spent.
14½ inches		Female	Do.	12 inches		Male	Do.
18 inches		Female	Do.	13 inches		Male	Do.
20 inches		Female	Do.	13 inches		Male	Do.
17½ inches		Female	Do.	12 inches		Male	Do.
23 inches		Female	Do.	11½ inches		Male	Do.
16 inches		Female	Do.	12 inches		Female	Do.
25 inches		Female	Do.	13½ inches		Male	Do.
12 inches		Female	Ripe.	14 inches		Male	Do.
13 inches		Male	Spent.	12 inches		Male	Do.
17½ inches		Male	Do.	9½ inches		Male	Do.
14 inches		Female	Do.	15 inches		Female	Do.
24 inches		Female	Do.	11 inches		Male	Do.
20 inches		Male	Do.	12½ inches		Female	Do.
18 inches		Female	Nearly ripe.	10½ inches		Male	Do.
21 inches		Female	Do.	12½ inches		Male	Do.
27 inches		Female	Spent.	13 inches		Female	Do.
21 inches		Female	Do.	11 inches		Male	Do.
25½ inches		Female	Not ripe.	10½ inches		Male	Do.
27 inches		Female	Spent.	12 inches		Male	Do.
23 inches		Female	Do.	10½ inches		Female	Do.
13 inches		Female	Do.	12½ inches		Male	Do.
15 inches		Male	Do.	12 inches		Female	Do.
25 inches		Female	Do.	12½ inches		Male	Do.
15½ inches		Female	Not quite ripe.	12½ inches		Male	Do.
				13½ inches		Female	Do.
14 inches		Male	Spent.	13½ inches		Female	Slightly developed.
30 inches		Female	Ripe.				
16½ inches		Female	Spent.	14 inches		Male	Spent.
20½ inches		Female	Do.	15 inches		Male	Do.
16½ inches		Female	Do.	13 inches		Female	Half ripe
17 inches		Female	Do.	13½ inches		Female	Spent.
25½ inches		Female	Do.	14 inches		Female	Do.
18 inches		Male	Do.	9½ inches		Male	Do.

Table showing size, sex, and spawning condition of blue catfish, etc.—Continued

Length.	Weight, pounds.	Sex.	Spawning condition.	Length.	Weight, pounds.	Sex.	Spawning condition.
12½ inches		Female	Partially developed.	17 inches		Male	Spent.
				14½ inches		Female	Do.
14 inches		Male	Spent.	16½ inches		Male	Do.
11½ inches		Male	Do.	26½ inches		Female	Ripe.
10½ inches		Male	Do.	31 inches		Female	Do.
15½ inches		Male	Do.	12½ inches		Female	Spent.
14 inches		Male	Do.	12½ inches		Female	Do.
13½ inches		Male	Do.	14 inches		Female	Do.
14 inches		Female	Do.	11 inches		(?)	(?)
14 inches		Male	Do.	21 inches		Female	Spent.
11 inches		Male	Do.	20 inches		Female	Do.
10 inches		Female	Do.	14½ inches		Female	Do.
12 inches		Male	Do.	14 inches		Female	Do.
15½ inches		Female	Do.	15 inches		Female	Do.
13½ inches		Female	Do.	16 inches		Male	Do.
14½ inches		Male	Do.	16 inches		Female	Do.
12½ inches		Male	Do.	15½ inches		Female	Do.
12½ inches		Male	Do.	10 inches		Female	Immature.
13 inches		Female	Do.	14½ inches		Male	Spent.
13 inches		Female	Do.	14½ inches		Female	Do.
11 inches		Female	Ripe.	16 inches		Female	Do.
17 inches		Female	Spent.	17 inches		Male	Do.
20½ inches		Female	Do.	21½ inches		Female	Do.
14½ inches		Female	Do.	13½ inches		Female	Do.
19 inches		Female	Do.	14½ inches		Male	Do.
21 inches		Female	Ripe.	15½ inches		Female	Do.
19½ inches		Female	Spent.	14 inches		Male	Do.
17 inches		Female	Ripe.	13 inches		Female	Do.
16½ inches		Female	Spent.	17 inches		Female	Do.
23 inches		Female	Do.	14 inches		Female	Do.
15 inches		Female	Do.	16 inches		Male	Do.
17 inches		Male?	Spent?	18½ inches		Female	Do.
13½ inches		Female	Spent.	13 inches		Female	Do.
15½ inches		Female	Do.	13½ inches		Female	Do.
10½ inches		Male	Do.	13½ inches		Male	Do.
22 inches		Female	Slightly developed.	12½ inches		Female	Do.
				13 inches		Male	Do.
20 inches		Female	Spent.	16 inches		Male	Do.
19 inches		Female	Do.	13½ inches		Male	Do.
16 inches		Female	Do.	26½ inches		Female	Do.
10 inches		(?)	Do.	16½ inches		Male	Do.
21½ inches		Female	Do.	22 inches		Female	Ripe.
15 inches		Female	Do.	13½ inches		Female	Spent.
13 inches		Female	Do.	12½ inches		Male	Do.
26½ inches		Female	Do.	11 inches		Female	Do.
16 inches		Female	Ripe.	14½ inches		Female	Do.
16½ inches		Female	Spent.	11½ inches		Male	Do.
21 inches		Male	Do.	16½ inches		Female	Do.
16½ inches		Female	Do.	16 inches		Female	Half developed.
19 inches		Female	Do.				
20½ inches		Female	Do.	16 inches		Male	Spent.
19 inches		Female	Do.	15 inches		Female	Do.
9½ inches		Male	Immature.	15½ inches		Female	Do.
12½ inches		Female	Spent.	11½ inches		Female	Do.
18 inches		Male?	Spent?	18 inches	3.50	Male	Do.
16 inches		Female	Spent.	17 inches	3.25	Female	Do.
13½ inches		Male	Do.	16 inches	3	Male	Do.
19 inches		Female	Spent.	41 inches	48	Female	Ripe.
16½ inches		Female	Do.	30 inches	17	Female	Spent.
15 inches		Female	Half ripe.	31 inches	22	Female	Do.
18½ inches		Male	Spent.	31 inches		Female	Ripe.
17½ inches		Male	Do.	20½ inches	6.50	Female	Do.
22½ inches		Female	Do.	24 inches	10.50	Female	Half ripe.
27 inches		Female	Ripe.	29 inches	14.25	Female	Spent.
20 inches		Female	Spent.	22½ inches	8.13	Female	Ripe.
20 inches		Female	Do.	20½ inches	6.5	Female	Do.
16½ inches		Female	Do.	17 inches	3.13	Male	Spent.
15 inches		Female	Do.	20 inches	5.75	Female	Ripe.
18 inches		Female	Do.	28 inches	13.25	Female	Spent.
18 inches		Female	Do.	25 inches	10.50	Female	Half ripe.
13 inches		Female	Half ripe.	31 inches	19.88	Female	Spent.
24½ inches		Female	Spent.	17 inches	2.13	Male	Do.
15½ inches		Female	Do.	15 inches	2	Female	Do.
15 inches		Female	Do.				

Table showing size, sex, and spawning condition of blue catfish examined at Melville, La., May 2 and 3, 1897.

Length.	Weight, pounds.	Sex.	Spawning condition.	Length.	Weight, pounds.	Sex.	Spawning condition.
16 inches	2.25	Male	(?)	19 inches	....	Male	(?)
15 inches	1.75	Male	(?)	15½ inches	....	Male	(?)
20 inches	5.25	Male	Ripe.	14½ inches	....	Male	(?)
15 inches	1.75	Female	Spent.	16½ inches	....	Female	Spent.
17 inches	3	Female	Do.	16½ inches	....	Female	Do.
18½ inches	3.50	Male		16 inches	....	Male	(?)
15 inches	2.50	Male	(?)	23 inches	....	Male	(?)
23 inches	7	Female	Spent.	15 inches	....	Female	Spent.
21 inches	6.50	Female	Ripe.	18 inches	....	Male	(?)
22½ inches	6.50	Male	Do.	15 inches	....	Male	(?)
15 inches	2	Male	(?)	15 inches	....	Female	Spent.
20½ inches	5	Female	Spent.	18 inches	....	Male	(?)
19 inches	4	Female	Do.	17 inches	....	Female	Ripe.
17½ inches	2.75	Male	(?)	19 inches	....	Female	Spent.
17 inches	2.75	Female	Spent.	15 inches	....	Female	Do.
18 inches	3.50	Female	Do.	16 inches	....	Female	Do.
15 inches	2	Female	Do.	17 inches	....	Male	(?)
15 inches	2	Female	Partly developed.	14½ inches	....	Male	(?)
				25 inches	....	Male	(?)
18 inches	3.50	Male	(?)	13½ inches	....	Female	Spent.
16 inches	2.25	Female	Spent.	17 inches	....	Female	Do.
16½ inches	2.25	Male	(?)	15 inches	....	Female	Do.
17 inches	2.75	Male	(?)	13½ inches	....	Male	(?)
15 inches	2	Male	(?)	14½ inches	....	Female	Ripe.
20 inches	5	Male	(?)	14½ inches	....	Male	(?)
26 inches	....	Female	Spent.	13 inches	....	Female	Spent.
19½ inches	....	Female	Do.	15½ inches	....	Female	Do.
31 inches	....	Female	Do.	13½ inches	....	Male	(?)
21½ inches	....	Female	Do.	13 inches	....	Male	(?)
22 inches	....	Female	Do.	16½ inches	....	Male	(?)
30 inches	....	Female	Do.	14 inches	....	Male	(?)
18 inches	....	Female	Do.	15½ inches	....	Female	Not ripe.
17 inches	....	Male	Do.	16½ inches	....	Female	Do.
18½ inches	....	Female	Do.	18 inches	....	Female	Do.
17 inches	....	Female	Do.	21½ inches	....	Male	(?)
26 inches	....	Female	Do.	19 inches	....	Female	Spent.
19 inches	....	Female	Ripe.	19 inches	....	Female	Do.
21 inches	....	Female	Spent.	13½ inches	....	Female	Do.
30 inches	....	Female	Do.	14½ inches	....	Female	Not ripe.
22 inches	....	Male	(?)	16 inches	....	Male	(?)
19 inches	....	Female	Spent.	15½ inches	....	Female	Spent.
22 inches	....	Female	Do.	14½ inches	....	Male	(?)
17 inches	....	Female	Do.	14 inches	....	Female	Spent.
16 inches	....	Female	Do.	18 inches	....	Male	Not ripe.
23 inches	....	Female	Do.	20 inches	....	Female	Spent,
18 inches	....	Female	Do.	17½ inches	....	Female	Do.
15½ inches	....	Female	Do.	18 inches	....	Female	Ripe.
17 inches	....	Male	(?)	16 inches	....	Male	(?)
25 inches	....	(?)	(?)	18 inches	....	Female	Spent.
18 inches	....	Female	Spent.	18 inches	....	Female	Do.
21 inches	....	Female	Do.	23½ inches	....	Female	Ripe.
22 inches	....	Female	Do.	19 inches	....	Female	Spent.
16 inches	....	Male	(?)	18½ inches	....	Female	Do.

Table showing size, sex, and condition of goujon examined at Morgan City, La., April 22–24, 1897.

Length.	Weight, pounds.	Sex.	Spawning condition.	Length.	Weight, pounds	Sex.	Spawning condition.
23 inches	....	Female	Ripe.	29 inches	14	Female	Spent.
24 inches	....	Female	Spent.	22½ inches	7⅛	Female	Ripe.
30 inches	....	Female	Do.	25 inches	10	Female	Do.
38 inches	....	Female	Do.	15 inches	....	Male	Immature.
28 inches	....	Female	Do.	28 inches	44	Female	Spent.
26 inches	....	Female	Half developed.	36 inches		Female	Ripe.
				28 inches		Female	Do.
24 inches	....	Male	Ripe.	34 inches	69½	Female	Spent.
37 inches	....	Female	Spent.	34 inches		Female	Ripe.
27¾ inches	....	Female	Do.	18 inches		Female	Spent.
25 inches	9	Female	Do.				

Table showing size, sex, and condition of eel catfish examined at Morgan City and Melville, La., April 22 to May 6, 1897.

Length.	Sex.	Spawning condition.	Length.	Sex.	Spawning condition.
13½ inches	Female	Ripe.	18 inches	Female	Ripe.
11½ inches	Female	Spent.	14 inches	Female	Do.
17 inches	Female	Do.	14 inches	Male	Do.
13½ inches	Female	Do.	16 inches	Female	Do.

Summary.

Species.	Total number examined.	Sex.			Spawning condition.				
		Male.	Female.	Sex not determined.	Spent.	Ripe.	Partially developed.	Immature.	Condition not evident.
Blue cat	374	126	227	21	257	32	17	18	50
Goujon	42	2	40	0	18	22	1	1	0
Eel cat	8	1	7	0	3	5	0	0	0

While exact measurements were made of only about 424 fish, several hundred more (perhaps 2,000) were examined more or less carefully, particularly with reference to their size. From these observations, as well as from the measurements recorded in the preceding tables, it is evident that a very large proportion of the fish now handled are comparatively small and young fish which have not yet attained that size which puts them at their maximum value. A few specific instances may be noted. Ten yellow cats dressed 83 pounds; one lot of 48 and another lot of 49 blue cats dressed 100 pounds, while another lot of 40 dressed only 50 pounds; in another case 70 blue cats were required to dress 100 pounds. According to one of the dealers, in 1881 from 14 to 20 of the smallest fish were sufficient to dress 100 pounds, while the larger fish were much more abundant than now and weighed each from 60 to over 100 pounds rough. He says the size began to decrease four years ago, but the greatest decrease has been during the last two years.

It is evident from these facts that these fish are being caught before they have reached that size which would render them of the greatest commercial value, and that some restriction should be placed upon the fishery with a view to regulate this matter.

At Melville the yellow cat or goujon was less common than at Morgan City. Mr. Chamberlain saw only about a dozen examples, all of which were ripe females.

From the above tables it will be seen that we examined and made notes upon 374 blue catfish, of which there were 227 females, 126 males, and 21 indeterminate. Of the total 374, 32 were in full roe and ripe, 17 contained roe partially developed, 18 were immature, 50 indeterminate, and 257 were spent fish. Omitting the 18 immature and the 50 indeterminate, we have 306 fish of which 257 (or 84 per cent) were spent fish, 32 (or about 10 per cent) were ready to spawn, while 17 (or about 5½ per cent) were not quite ready for spawning.

So far as the investigations of a single season may be relied upon, these results indicate that the spawning season of the blue catfish in the Atchafalaya River is a prolonged one, but that the majority of the fish spawn in March and April. The testimony given by the fishermen agrees closely with these results. They report finding fish in full roe as early as the last of February and as late as the first of June, though all admit that the majority of ripe fish are taken in March or April.

The total number of goujon examined was 42, of which all but 2 were females. Of the 2 males, one was an immature fish and the other was fully ripe. Of the 40 females, 18 (or 45 per cent) were spent fish, 1 was about half developed, 1 was immature, while 22 (or 55 per cent) were ready to spawn. This indicates for the goujon a somewhat later spawning season than for the blue cat, of which about 84 per cent were done spawning. The few eel cats examined showed that about 38 per cent had already spawned and that 62 per cent were ready to spawn.

The number of spotted cats examined was not sufficient to enable any conclusion to be drawn as to its time of spawning.

Basing conclusions as to the time of spawning period upon investigations extending over only a brief portion of a single season is not altogether safe. Accurate results can only be obtained from observations extending over two or more seasons. All that can be said, therefore, in this report, is that the strong probability is that the great majority of catfish in Atchafalaya River spawn in March and April, the period from March 15 to April 30 being the most important.

Method of handling the fish.—Each fisherman visits his lines daily, or twice a day if possible, passing from hook to hook in his pirogue, taking off the fish and putting them in live-boxes where they are retained until the tugboat arrives on its regular collection trip. Each of the three companies at Morgan City has a tugboat for this purpose, valued at $2,000 to $3,000. Each tug carries in tow a large live-box called a live-car or fish-car, into which the fish are put when received from the individual fisherman and in which they are retained until they are needed for dressing. The car is usually 25 to 30 feet long, 6 feet beam, and is divided into several compartments. The maximum capacity is 40 to 50 boxes of 300 pounds each. The captain of the tug, as agent for the company, buys the fish from the fishermen. The fish are measured in a box 1½ by 1½ by 3 feet. This measuring-box rests upon the live-car over the particular compartment into which the fish are to be put, and when the box is full the hinged bottom is released and the fish fall into the car. A "box" of fish is 300 pounds, and the price paid during the time of our visit was $7 per box or about 2⅓ cents per pound. If any fisherman is not satisfied with the measured or estimated weight, the actual weight is determined. The highest price recently paid was $8 per box. Each firm's tug usually makes one trip, sometimes two, per week, the time required varying from three to five days.

A brief account of a trip which we took on the *Shamrock*, Captain Hanson, belonging to Mr. John Dalton, will be useful in conveying a proper conception of the fishery. We left Morgan City at noon, April 19, passing up the Atchafalaya River, through Grand Lake, Chicot Pass, Lake Chicot, and into Bayou Chêne, where we tied up for the night at Mr. Charles Larson's, about the only house on dry land that was seen during the entire trip. Next morning we passed out of Bayou Chêne into Lake Mangoulois, then through Bayou Tensas, Upper Grand River, Whisky Bayou, Bayou de Glaise, Bayou Alabam (Alabama Bayou), to Bayou des Ourse, where we tied up in the woods alongside the house-boat of William Kleinpeter. The next morning we went from Bayou des Ourse by another route into Whisky Bayou, then through Bayou la Rompe, Bayou la Rose, Butte à la Rose, Little Atchafalaya River, Upper Grand River, Bloody Bayou, Bayou Sorrel, and Jakes Bayou, thence back to Morgan City through Lake Chicot, Chicot Pass, Grand Lake and Atchafalaya River.

During this trip of about 180 miles fish were purchased from 25 fishermen. The amounts paid each fisherman varied from 70 cents to $18, the average being $6.84. The total fare collected on this trip was therefore about 25 boxes. The fares of two other tugs the same week were respectively 13 and 16 boxes. It was noticed on this trip that a good many fish die before reaching Morgan City. Some die even in the fishermen's live-boxes. The goujon seems much more hardy than the blue cat, as none of that species died on this trip, while more than 100 of the blue cats died. The goujon is said also to be a better shipper than the other species. When the tug returns to Morgan City it leaves its car alongside its company's fish-house. The fish are then taken out and dressed and barreled for shipment. The dressing consists in cutting off the head, removing the viscera, and skinning the fish, after which it is washed, and then barreled with ice for shipment. The principal shipments are made to Texas, Oklahoma, Kansas, Missouri, Colorado, and New Mexico.

During the summer months the loss from the fish dying in the live-cars and the difficulty of shipping them in good condition usually cause the tugs to stop running or to make fewer trips between June 1 and September 1. While some fishing is carried on during summer, the season may properly be regarded as extending from September 1 to June 1.

The catfish industry at Morgan City had its beginning about 1873. Not much was done, however, for several years. Complete statistics are not obtainable for any year previous to 1892, but we have been able to obtain complete statistics for the years 1892 to 1897, inclusive, of the catfish shipped from Morgan City. These are exhibited in the following table. The fish shipped from Morgan City are caught chiefly at various places above that town. Indeed, the Morgan City boats go within a few miles of Melville.

Table showing by months the gross weight and value of catfish handled at Morgan City, La., during the years 1892 to 1897, inclusive.

Year.	January.		February.		March.		April.	
	Pounds	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
1892	117, 908	$2, 947. 70	120, 108	$3, 002. 70	196, 591	$4, 914. 77	110, 820	$2, 770. 50
1893	89 976	2, 249. 40	115, 825	2, 895. 62	168, 870	4, 221. 75	117, 204	2, 930. 10
1894	133. 520	3, 338. 00	109, 675	2, 741. 87	107, 182	2, 679. 55	120, 051	3, 001. 27
1895	124, 152	3, 724. 56	118, 228	3, 546. 84	262, 920	7, 887. 60	256, 384	7, 691. 52
1896	93. 718	2, 811. 54	97, 820	2, 934. 60	179, 236	5, 377. 08	150, 994	4, 529. 82
1897	66, 565	1, 996. 95	49, 370	1, 481. 10	140, 359	4, 210. 77	80, 706	2, 421. 18

Year.	May.		June.		July.		August.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
1892	43, 776	$1, 094. 40	8, 535	$213. 37	1, 272	$31. 80	446	$11. 15
1893	63, 307	1, 582. 67	6, 592	164. 80	1, 351	33. 77	14, 213	355. 32
1894	65, 323	1, 633. 07	12, 701	317. 52	11, 804	295. 10	26, 175	654. 37
1895	269, 513	8, 085. 39	68, 593	2, 057. 79	15, 281	458. 43	10, 880	328. 40
1896	145. 144	4, 354. 32	31, 124	933. 72	32, 186	965. 58	13, 077	392. 31
1897	57, 488	1, 865. 65	50, 528	1, 629. 85	47, 159	1, 509. 28	33, 323	1, 082. 19

Year.	September.		October.		November.		December.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
1892	36, 128	$903. 20	48, 468	$1, 211. 70	196, 933	$4, 923. 32	134, 430	$3, 360. 75
1893	59, 967	1, 499. 17	38, 778	969. 45	200, 624	5, 015. 60	134, 475	3, 361. 87
1894	35, 501	919. 36	125, 562	3, 265. 06	193, 132	5, 453. 93	153, 827	4, 337. 44
1895	83, 121	2, 493. 63	98, 523	2, 955. 69	180, 089	5, 402. 67	133, 558	4, 006. 74
1896	22, 533	675. 99	86, 300	2, 589. 00	103, 762	3, 112. 86	89, 518	2, 685. 54
1897	26, 675	849. 76	(*)	(*)	75, 475	2, 264. 25	147, 341	4, 420. 24

* On account of the yellow fever quarantine from September 21 to November 13 no fish were shipped from Morgan City between those dates.

CONCLUSIONS.

That the fishery industry of the Atchafalya River has seriously decreased in importance during the last few years is evidenced by the foregoing statistical table, though the actual decrease in abundance of these valuable fishes is only partially shown. The great falling-off in the catch of 1896 and 1897 over that of 1895 is such as to seriously threaten the industry. Until recently only the larger fish were accepted by the dealers. The fishermen liberated and returned to the water all the individuals of small size. But during the last two years the great difficulty of getting a sufficient number of large fish to supply the demand has induced both the fishermen and the dealers to utilize the smaller fish. The tendency has been to accept smaller and smaller fish each succeeding season until now a great many are used which dress scarcely more than a pound each. When it is remembered that these small fish, if allowed to escape for a few years, would attain a weight of 20 to 100 pounds, the improvidence of the methods now in vogue becomes apparent.

The injury to the fishery resulting from the catching of undersized fish is not the only one from which the industry is suffering. The continuance of fishing throughout the spawning season must result disastrously to the business. The destruction of the fish when nearly ready to spawn can not be defended on business grounds. Every large female, if permitted to live through the spawning season, will produce from

50,000 to 250,000 young; 1,000 such fish would produce from 50,000,000 to 250,000,000 young. It is, of course, impossible to say how many would live and grow to maturity, but that the number would be quite adequate to greatly improve the fishery can not be doubted.

The importance of these facts has already impressed the dealers. They realize that something must be speedily done to prevent the practical extinction of the business in which they are engaged. The fishermen are also beginning to realize that the methods in vogue are destructive and detrimental to any permanent fishery interests. So strongly impressed are both dealers and fishermen with the threatened destruction of the fishing interests of the Atchafalaya River that they are anxious that the State enact legislation for their preservation. In the absence of any law regulating the fishery it is scarcely possible to secure any united action among the various ones interested looking toward the conservation of the supply.

While the investigations were limited to the Atchafalaya River, and chiefly to that portion of the river tributary to Morgan City, there is every reason to believe that the catfish supply is diminishing throughout the State. The brief investigations made at Melville and reports received from Plaquemine agree fully with the results obtained at Morgan City.

RECOMMENDATIONS.

In the light of the foregoing facts, it is evident that State legislation is essential to the preservation of the catfish fishery of the Atchafalaya River and in the other waters of the State. The State legislature should, at its first opportunity, enact a law regulating fishing in the State, which should be reasonable and fair to all the interests concerned. This law should provide (1) for a close season extending from March 15 to May 15, which period covers the principal spawning season of the two important species of catfish, and (2) it should be made unlawful to catch catfish of less than 4 pounds gross weight.

SABINE AND NECHES RIVERS.

The investigations and inquiries in eastern Texas and western Louisiana were made primarily for the purpose of determining the advisability of making plants of shad in the Sabine and Neches rivers. The time was insufficient for making a satisfactory series of observations, therefore such conclusions as have been reached are purely tentative and may be materially modified when more thorough investigations shall have been made.

The only places visited were Beaumont, Lufkin, Michelli, and Logansport. The Neches River was examined at Beaumont and at Bonners Ferry, 10 miles west of Lufkin. The Angelina River, a tributary of the Neches, was examined at Michelli, 9 miles north of Lufkin. The Sabine River was inspected at Logansport.

While at Beaumont a visit was made to some ponds and a small creek near town, from which were obtained specimens of a number of

the native fishes. All of these rivers at the time of our visit were considerably above their ordinary stage of water. At the railroad bridge across the Neches at Beaumont the river was about 300 feet wide and 30 feet deep, being at least 2 feet higher than usual at that season. The water was very muddy and the banks were covered with soft mud. We were told that the water of this river never becomes clear, but always remains nearly or quite as muddy as it then was.

There is usually a rise in the river early each spring and another later, which is known as the "June rise." In June, 1884, it was said to have been about 15 feet higher than when seen by us.

Lake Sabine, into which flow both the Neches and Sabine rivers, is some 28 or 30 miles long and 2 or 3 miles wide, and is always salt or brackish. Such fishes as red drum, sheepshead, and sea trout are caught in large numbers in this lake and about Sabine Pass.

The principal fishes found in the two rivers near Beaumont are blue cat, yellow cat, buffalo, gaspergou, and gar.

At Bonners Ferry the Neches River was several feet above low-water mark and had been higher recently. The banks had been overflowed and were still very muddy. The soil of the region consists of yellow clay, with some sand. The river at this place was about 40 feet wide and was flowing with a strong current. The water was red with clay mud carried in suspension. The temperature of the water, at 10 a. m. April 28, was 70°.

Among the fishes occurring in this portion of the river are the blue cat, said to reach a weight of 85 pounds; goujon, or "Opelousas cat" (*Leptops olivaris*), reaching a weight of 100 pounds; black and white buffalo, each attaining a weight of 20 to 35 pounds; gaspergou, which grow to 20 pounds; alligator gar, reaching a length of 7 or 8 feet; sun perch; large-mouth black bass (locally called green trout), common in the ponds; hickory shad or "scissor belly" (*Dorosoma cepedianum*); spoonbill cat; and grindle (*Amia calva*) in the ponds. Carp, which were planted in this river several years ago, are said to be rather common now and are regarded as a good food-fish.

The Angelina River at Michelli was at the time of our visit 40 to 50 feet wide and 10 to 14 feet deep. It was said to be 5 or 6 feet higher than usual and was overflowing its banks. The water was very muddy and full of floating débris. The temperature of the water at 3 p. m., April 28, was 72.5°, when the air was 80.5°. Some collecting was done in a small bayou and in some overflow ponds, and the following species obtained: Large-mouth black bass, 1 species of sunfish (*Lepomis garmani*), calico bass, 3 species of darters (*Percina caprodes*, *Boleosoma camurum*, and *Etheostoma jessiæ*), pirate perch, skipjack, top minnow (*Fundulus notatus*), *Fundulus pallidus*, *Gambusia affinis*, little pickerel, *Notropis notemigonoides*, *Notropis venustus*, *Cliola vigilax*, roach (*Abramis crysoleucas*), *Opsopœodus emiliæ*, and *Hybognathus nuchale.* The following additional species are reported by fishermen to occur there: Goujon or "abaloosie," blue cat, white buffalo, black buffalo, "shovel-bill" cat, gaspergou, alli-

gator gar, white gar, hickory shad, red perch, and white perch. The goujon is said to reach a weight in this river of 50 to 75 pounds. The blue cat reaches about the same size, and is more abundant.

The Sabine River at Logansport is quite a large river, which, like all other streams in that region, was considerably above its usual stage at the time of our visit, and, like the other streams, was red with mud which it was carrying. The temperature of the water was 70° at 10 a. m. April 29, when the air was 65°.

The more abundant fishes seen by us or reported by the fishermen are yellow cat and blue cat, said to spawn in the summer, which is probably an error; drum or gaspergou, reaching a weight of 20 pounds and said to spawn in April and May; white buffalo, reaching a weight of 35 pounds, and black buffalo, reaching about the same size, both species spawning in March. The very large goujon are here called "Opiloosa" (Opelousas), and are described as having a flat head and reaching a great size. The head of one large example recently taken weighed 20 pounds.

The fishermen speak of the carp as the "Government fish," and say that they are regarded as a good fish and find a ready sale.

Fishing here is not of much commercial importance and is almost wholly for local trade. It is carried on with hoop nets baited with dough, etc. A hoop net lifted during our visit contained one small gaspergou and two white buffalo, one of which weighed 11 pounds.

No evidence of the existence of any species of the true shad (*Alosa*) in either of these rivers could be secured. The commercial fishermen know nothing about such fish. It must be borne in mind, however, that the methods employed by the fisherman are not such as would result in the capture of such fish as the shad. The apparatus used in this region consists simply of set lines and a few hoop nets, which are, of course, useless in a shad fishery. Shad may be common in these rivers and entirely escape observation until they are fished for with suitable apparatus and at the proper season.

LAKES TASSE AND PEIGNEUR.

Lake Tasse, or Spanish Lake, is a small and shallow body of water about 7 miles northwest of New Iberia, La. It is about 2 miles long and 1 mile wide. It has no inlets, but is supplied entirely by rains. Two artificial outlets connect it with Bayou Têche. The water is necessarily quite warm in the summer, and is full of *Nelumbo*, *Nuphar*, *Nymphæa*, *Myriophyllum*, and other aquatic vegetation. The following fishes are said to occur in this lake: Large-mouthed black bass, or "green trout," reaching a weight of 6 to 10 pounds; sac-a-lait, goggle-eye, bream, sunfish, barfish (*Roccus chrysops*), pike (*Lucius vermiculatus*), gar, grindle, goujon, blue cat, gaspergou, and buffalo. Alligators are also very abundant.

Lake Peigneur is situated 10 miles west of New Iberia, on the country place of Mr. Joseph Jefferson. It is a beautiful lake about 1½ miles

wide and 3 miles long. The greatest depth is said to be 10 feet, and the water is much freer from vegetation than Lake Tasse. The shores are also much higher and more picturesque. The fishes are essentially the same as those of Lake Tasse.

LIST OF FISHES.

The following list includes all the species of fishes collected or seen at the various places visited and such additional species as were reported upon authority considered reliable. The nomenclature and sequence of species agree with Jordan & Evermann's Check-List of Fishes and Fish-Like Vertebrates of North and Middle America.

The localities and waters represented are:

1. Various waters in the vicinity of Baldwin Lodge, Mississippi, including Pearl River, Lake Borgne, Bayou Isle aux Pois (or Campbell Bayou), Grand Plains Bayou, Lagoon Bayou, Black Bayou, and Mulatto Bayou.
2. Atchafalaya River at Morgan City and Melville, La., and intermediate points.
3. Lake Tasse, or Spanish Lake, 7 miles from New Iberia, La.
4. Lake Peigneur, 10 miles west of New Iberia, La.
5. Neches and Trinity rivers and some small ponds near Beaumont, Tex.
6. Neches River at Bonners Ferry, 10 miles west of Lufkin, Tex.
7. Angelina River at Michelli, Tex., 9 miles north of Lufkin, Tex.
8. Sabine River at Logansport, Tex.

Common names used locally are inclosed in quotation marks.

1. **Polyodon spathula** (Walbaum). *Spoonbill Cat*; "*Shovel-nose Cat*"; "*Shovel-bill Cat.*" Reported from the Neches, Angelina, and Sabine rivers by fishermen at Bonners Ferry and Michelli.
2. **Lepisosteus osseus** (Linnæus). *Long-nosed Gar*; "*Gar*"; "*Garfish*"; "*Poisson armé.*" This species was seen at Morgan City and reported from Baldwin Lodge, Melville, Lake Tasse, Lake Peigneur, Beaumont, Bonners Ferry, Michelli, and Logansport. On April 23, the following notes were taken on a spawning female gar at Morgan City: Standard length, 40 inches; weight, 9 pounds; length of snout, 8.5 inches; weight of ovaries, 19 ounces; total number of eggs by actual count, 36,450.
3. **Lepisosteus platostomus** Rafinesque. *Short-nosed Gar*. Seen only at Beaumont, when several specimens were seined in a pond.
4. **Lepisosteus tristœchus** (Bloch & Schneider). "*Alligator Gar*"; "*Mississippi Gar.*" Seen in Lake Borgne, at Morgan City, and at New Iberia (a specimen from Bayou Têche); reported from Bonners Ferry, Logansport, and Beaumont.
5. **Amia calva** Linnæus. *Bowfin*; *Grindle*; "*Grinnel*"; "*Poisson de Marais.*" Reported from Lakes Tasse and Peigneur, and from the Neches River.
6. **Felichthys marinus** (Mitchill). *Gaff-topsail*; "*Sea Cat.*" Seen at Morgan City. The larger ones are sometimes dressed and shipped with the fresh-water species.
7. **Galeichthys felis** (Linnæus.) *Sea Catfish*; "*Sea Cat.*" Seen with the preceding at Morgan City, where it is sometimes utilized in the same way.

8. Ictalurus furcatus (LeSueur). *"Blue Cat"*; *"Poisson Bleu."*

This is by far the most important of all the catfishes of the region covered by this report. It attains a weight of 100 pounds, and the importance of the species is shown in the earlier portions of this paper. Its abundance, distribution, and habits have already been fully discussed. Until these investigations were made the large catfish of the Lower Mississippi Valley had been identified by most ichthyologists as the *Gadus lacustris* of Walbaum. *Pimelodus nigricans* LeSueur and *Amiurus ponderosus* Bean were thought to belong to the same species as Walbaum's *Gadus lacustris*, and the species stood as *Ameiurus lacustris* (Walbaum). The type of *Gadus lacustris* came from Arctic America, and we have no certain means of knowing whether it was an *Ameiurus* or an *Ictalurus*. LeSueur's *Pimelodus nigricans* came from Lakes Erie and Ontario, and was probably an *Ameiurus*, though a reexamination of specimens from those lakes must be made before we can feel certain that such is the case. An examination of the skeleton of the type of *Amiurus ponderosus*, which is preserved in the U. S. National Museum, shows that it belongs to the genus *Ictalurus*, as is evidenced by the notched supraoccipital which forms a continuous bony ridge with the first interspinal of the dorsal. LeSueur's *Pimelodus furcatus* came from New Orleans and was unquestionably the same as the blue cat of the Atchafalaya River. At least until the large catfish of the Great Lakes can be carefully studied, the blue cat of the Lower Mississippi Valley must stand as *Ictalurus furcatus*, and *Amiurus ponderosus* goes in its synonymy.

The number of anal rays in numerous specimens counted varies from 31 to 33. A spent female, 30 inches long and weighing 17 pounds, gave the following measurements: Head 4; depth 4.34; D. I, 6; P. I, 9; A. 32; distance from tip of snout to origin of dorsal fin 2.64 in body; greatest width of head 1.34 in its length; interorbital width 2; width of mouth equals interorbital width; maxillary barbel not reaching beyond head; humeral process about 3 in pectoral spine; anal base nearly $\frac{1}{3}$ longer than head. Barbels usually color of fish, rarely black. In other respects the description of *Ameiurus lacustris* in Jordan & Evermann's Fishes of North and Middle America agreed perfectly with this specimen. The color of this species, as found in the Atchafalaya River, is a dull or olivaceous blue, pale or whitish below, without spots anywhere.

9. Ictalurus anguilla Evermann & Kendall. *"Eel Cat"*; *"Willow Cat."*

The following is the original description of this species: Head 4; depth 4.5; eye 7 in head; snout 2.8; maxillary (without barbel) 3; free portion of maxillary barbel longer than head; dorsal spine 2 in head; pectoral spine 2; width of mouth 2. D. I, 6; A. 24; vertebræ 42. Head large, broad, and heavy; mouth unusually broad; cheeks and postocular portion of top of head very prominent; interorbital space flat, a broad, deep groove extending backward to origin of dorsal fin; body stout, compressed posteriorly; back scarcely elevated. Eye small; maxillary barbel long, reaching considerably past gill-opening; other barbels short. Origin of dorsal fin equidistant between snout and origin of adipose fin, its distance from snout 2.6 in length of body; base of dorsal fin 3.5 in head; longest dorsal ray 1.75 in head; dorsal spine strong, entire both before and behind; pectoral spine strong, entire in front, a series of strong retrorse serræ behind; humeral process 2.2 in pectoral spine; ventrals barely reaching origin of anal, their length 2 in head; anal fin long and low, the longest rays about 2.2 in head; base of fin greater than head, 3.2 in body; caudal moderately forked, the middle rays about 2.2 in outer rays, which are about 1.4 in head.

Color, uniform pale-yellowish or olivaceous; no spots anywhere.

A comparison of the skull with that of *I. furcatus* and *I. punctatus* of the same size shows a number of very marked differences. Nearly all the bones

in *I. anguilla* are heavier than in the other species; the supraoccipital is broadly triangular and its upper surface finely grooved, while in each of the other species it is much longer and narrower and the upper surface is nearly smooth.

An examination of the 6 cotypes shows that there is not much variation, all the important characters remaining quite constant. The maxillary barbel varies somewhat in length, in some individuals scarcely reaching the gill-opening, and the number of anal rays varies from 24 to 26.

From the blue cat (*I. furcatus*) this species differs chiefly in the fewer rays in anal fin, the wider mouth, shorter, heavier head, much longer maxillary barbel, and in the cranial characters already given. From the spotted cat (*I. punctatus*) it may be distinguished by its wider mouth, more blunt snout, heavier head, the color, and the cranial characters already mentioned.

This species is well known to the fishermen of the Atchafalaya River, by whom it is usually called the "eel cat," though the name "willow cat" is sometimes applied to it. It was explained by the fishermen that the name "eel cat" was given on account of the long feelers (i. e., barbels), and the name "willow cat" because it is most frequently found about the roots of willow trees. The eel cat is not an abundant species in the Atchafalaya River. During six days spent at Morgan City (April 19-24) several hundred catfish were examined at the three fish-houses, and the total number of eel cats seen was fewer than twenty-five. The fishermen report that this proportion is about as great as at any time of the year. Of four commercial species of catfishes handled on this river, the most abundant one is the blue cat (*Ictalurus furcatus*), and the next is the yellow cat or goujon (*Leptops olivaris*). The eel cat comes next and the spotted cat (*Ictalurus punctatus*) last. The blue cat and the yellow cat probably constitute 98 per cent of the entire catch.

The eel cat rarely weighs over 5 pounds, and usually not over 3 pounds. Its flesh is firm and of excellent flavor. The spawning season appears to be during the spring, as several individuals examined were in mature spawning condition. In May, 1898, the writer found a few specimens of this species in the Ohio River at Louisville, Ky.

One of the species of large catfish seen in the market at Houston, Tex., in 1891, was called "eel cat" by some of the dealers. The specimens came from the lower Trinity and San Jacinto rivers, and were identified as *Ictalurus furcatus*, which they undoubtedly were. The name "eel cat" was also heard at the mouth of Pearl River, but no specimens were obtained. This name is probably applied in different localities to different species.

10. Ictalurus punctatus (Rafinesque). "*Spotted Cat*"; *Channel Cat.* This species is very rare in the Atchafalaya River. Only one adult was seen among several hundred fish examined at Morgan City. Four young were seined in Lake Lapourde, near that town. Apparently this species is much less common in Louisiana than has usually been supposed.

11. Ameiurus nebulosus (LeSueur). *Common Bullhead.* Three small specimens were obtained in a pond near Beaumont.

12. Ameiurus melas (Rafinesque). *Black Bullhead.* One specimen 7 inches long and 2 smaller ones from Angelina River at Michelli.

13. Leptops olivaris (Rafinesque). "*Goujon*"; "*Yellow Cat*"; "*Peided Cat*"; "*Mud Cat*"; "*Opelousas Cat.*" Next to the blue cat this is the most abundant and important food-fish in the Atchafalaya River. It was also seen by us at Baldwin Lodge, and it was reported at Beaumont, Bonners Ferry, Michelli, Logansport, and Lakes Tasse and Peigneur.

14. Schilbeodes gyrinus (Mitchill). *Small Poison Cat.* Two good specimens of this species were obtained, one from Black Bayou near Baldwin Lodge and one from Lake Lapourde at Morgan City.

15. Ictiobus cyprinella (Cuvier & Valenciennes). *Common Buffalo-fish*; "*Gourd-head Buffalo.*" This species is common in all the larger waters of the region visited, and is a food-fish of considerable importance, especially at Morgan City, Melville, Beaumont, and Logansport. It is described by the fishermen as having the mouth larger than any other species and "straight out," and feeding more at the top of the water.

16. Ictiobus urus (Agassiz). "*Black Buffalo*"; "*Chopper.*" Occurs in the Atchafalaya, Neches, and Sabine rivers. Reaches a weight of 35 pounds or more. Head and mouth larger than in *I. bubalus*. Said to spawn in March and April.

17. Ictiobus bubalus (Rafinesque). *Small-mouthed Buffalo*; "*White Buffalo*"; "*Rooter.*" Common in the Atchafalaya River and all bayous, rivers, and lakes of this region; seen by us at Morgan City, Beaumont, Melville, and Logansport. Reaches a weight of 35 pounds or more. Spawns in March and April. Described by the fishermen as having a smaller, more inferior mouth than any other species, and as being more of a bottom feeder. All three of these species are used as food. A specimen 16 inches in total length from the Sabine River at Logansport, La., taken April 29, exhibits the following characters: Head 4; depth 2.5; snout 3.34 in head; eye 5. D. 28; A. 11. Scales 9-35-5, 12 or 13 before the dorsal. Body short, compressed, the dorsal profile strongly arched and subcarinate from occiput to origin of dorsal fin; ventral outline only slightly convex. Head small; mouth small, subinferior, protactile downward; lips papillose; opercles striate; caudal peduncle deep and compressed, its least depth 1.75 in head. Fins moderate, first 7 or 8 dorsal rays lengthened, as long as head, rays of the short portions 3.5 in head; longest anal rays 1.17 in head; pectoral short, not reaching base of ventral, 1.4 in head; ventrals longer, 1.1 in head; caudal deeply lunate, the lobes longer than head.

18. Hybognathus nuchale Agassiz. *Silvery Minnow.* Two specimens in the collection from the Angelina River. Others were examined on the Atchafalaya River 70 miles above Morgan City.

19. Hybognathus hayi Jordan. Two specimens from Melville.

20. Opsopœodus emiliæ Hay. Sixteen from Angelina River at Michelli and 6 from Beaumont. Lateral line complete in all. In many there are two black areas on dorsal fin; the anterior four rays and their membranes are black, then comes a white streak covering one or two rays, then another black streak on the last three rays. In a few of the smaller specimens there is no black on the dorsal; where there is any black, it is in two spots or bands.

21. Abramis crysoleucas bosci (Cuvier & Valenciennes). *Roach.* Three examples from Michelli. Not seen elsewhere, though it doubtless occurs in most of the waters examined.

22. Cliola vigilax (Baird & Girard). Three specimens from Michelli, the largest of which (3 inches long) has the head 4.13; depth 4; eye 3.75 in head; snout 3; scales 8-45-5, 26 before the dorsal; D. I, 8; A. 7.

23. Notropis nux Evermann. Eight examples from Beaumont, Tex. Head 4; depth 3.75; eye 3; snout 4; D. 8; A. 7; scales 7-35-3, 13 before dorsal. Teeth 1, 4-4, 1, hooked, and with slight grinding surface. Mouth rather small, lower jaw somewhat included; origin of dorsal over insertion of ventrals. A small spot at base of caudal. Scales rather deeper than long. These specimens agree in the main with cotypes of *N. nux*, but the depth is greater. This last is due to the fact that all these specimens are well fed and many of them full of spawn.

24. Notropis chamberlaini Evermann.

Type, No. 48901, U. S. Nat. Mus.; cotypes, No. 707, U. S. F. C. Length of type, 3 inches to base of caudal. Type locality, Atchafalaya River, Melville, La. Collector, Fred. M. Chamberlain, May 5, 1897.

Head 4.34; depth 4.2; eye 4; snout 4; D. 8; A. 10; scales 7-39-4, about 15 before dorsal. General form much like that of *Hybognathus;* body only moderately compressed, dorsal and ventral outlines slightly arched; head rather small, pointed; mouth small, a little oblique, the maxillary scarcely reaching anterior border of orbit, lower jaw slightly included; snout equal to eye; eye in axis of body. Fins all rather small; origin of dorsal slightly behind vertical at insertion of ventrals; free edge of dorsal fin somewhat concave, the anterior rays about equal to length of head; pectoral short, slightly falcate, the longest rays about 1.4 in head; ventrals shorter than pectoral, barely reaching vent; anal similar to dorsal, the rays shorter; caudal widely forked, the middle rays 2.5 in the outer, the lobes as long as head, the lower lobe slightly longer than the upper; scales moderately imbricated, the exposed portions not deeper than long; lateral line complete, somewhat decurved. Teeth 2, 4-4, 2 or 1, rather weak, hooked, and with small grinding surface. Intestine short; peritoneum silvery.

General color light straw; middle of side with a broad, well-defined silvery band from upper end of gill-opening to middle of base of caudal fin, the anterior half lying wholly above the lateral line, the posterior portion lying partly below it; this silvery band bounded above by a narrow dark border; cheeks and opercles silvery; a darkish band along median line of back; fins all plain straw-color or pale lemon.

Fourteen examples of this species, 2 to 3 inches in length, were obtained from the Atchafalaya River at Melville, La., by Mr. Fred. M. Chamberlain, for whom the species is named.

25. Notropis louisianæ Evermann.

Type, No. 48902, U. S. Nat. Mus.; cotype, No. 708, U. S. F. C. Type locality, Atchafalaya River, Melville, La. Collector, Fred. M. Chamberlain.

Head 4.5; depth 5.6; eye 3; snout 3; D. 8; A. 11; scales 7-37-3, 19 or 20 before the dorsal. Teeth 1, 4-4, 2, little hooked; peritoneum silvery, with numerous minute round black specks. Body long and slender, back not arched; head short but pointed; mouth rather large, oblique, maxillary scarcely reaching orbit; lower jaw somewhat included; eye large, equal to or greater than snout. Fins rather small; origin of dorsal far behind insertion of ventrals, its longest rays 1.4 in head; pectorals short, their length equal to height of anal; ventrals very short, 2 in head, caudal deeply forked; scales firm, moderately imbricated; lateral line complete, gently decurved. Color pale; side with a faint plumbeous band; back and upper part of sides with numerous dark specks chiefly on the margins of the scales, thus forming cross-hatchings; a narrow dark vertebral band on caudal peduncle. Length 2.5 inches. Known only from the Atchafalaya River, Louisiana.

This species resembles *Notropis dilectus*, but has a much smaller mouth, blunter snout, and is less silvery along the side.

26. Notropis venustus (Girard). Two specimens from Michelli.

27. Notropis notemigonoides Evermann. Two specimens from Michelli and 11 from ponds near Beaumont.

28. Anguilla chrysypa Rafinesque. Baldwin Lodge and Atchafalaya River, though not abundant. Considered excellent catfish bait by the Atchafalaya River fishermen.

29. Hiodon alosoides (Rafinesque). *Toothed Herring*; *La Quesche*; "*Slicker.*" One specimen from Melville; seen at other places along the Atchafalaya River, where it is used as bait in the catfish fishery. The specimen from Melville agrees exactly with more northern examples.

30. Dorosoma cepedianum exile Jordan & Gilbert. *Hickory Shad*; "*Shad.*" Rather common in the Atchafalaya River, where it is of considerable importance as bait. Four specimens from Melville. Doubtless occurs in most waters of this region.

31. **Signalosa atchafalayæ** Evermann & Kendall. "*Shad.*" Specimens of this interesting species were obtained at Melville and from Grand Plains and Black bayous. It is not rare in the Atchafalaya River, and is of some importance as bait in the catfish fishery.
32. **Brevoortia tyrannus patronus** Goode. *Gulf Menhaden.* Many very young examples obtained from Grand Plains Bayou.
33. **Stolephorus mitchilli** (Cuvier & Valenciennes). Numerous specimens from Baldwin Lodge and Lake Lapourde.
34. **Lucius vermiculatus** (LeSueur). *Little Pickerel.* Four small specimens from Michelli and 4 from Beaumont.
35. **Fundulus pallidus** Evermann. One example from Michelli.
36. **Fundulus grandis** Baird & Girard. Three from Baldwin Lodge.
37. **Fundulus pulvereus** (Evermann). Found only at Baldwin Lodge, where 4 specimens were collected.
38. **Fundulus chrysotus** Holbrook. Five specimens from Beaumont and 3 from Lake Lapourde.
39. **Fundulus notatus** (Rafinesque). Numerous fine examples from Michelli.
40. **Lucania venusta** (Girard). Common in Grand Plains Bayou and Lake Lapourde.
41. **Cyprinodon variegatus** Lacépède. Five examples from Baldwin Lodge.
42. **Gambusia affinis** (Baird & Girard). Numerous specimens from Grand Plains Bayou, Lake Lapourde, Beaumont, and Michelli. Four females from Michelli contained 60, 70, 73, and 114 well-developed embryos, respectively; the eyes were beginning to show. Six well-advanced examples from Lake Lapourde contained 8, 51, 18, 13, 16, and 20 embryos each. Five others from Lake Lapourde were less advanced. Numerous specimens from Michelli, Baldwin Lodge, and Beaumont were well advanced. The number of young seems to vary with the size of the fish. Very few males were collected.
43. **Mollienisia latipinna** (LeSueur). Numerous fine specimens from Baldwin Lodge.
44. **Siphostoma scovelli** Evermann & Kendall. *Pipefish.* Six from Lake Lapourde and 4 from Grand Plains Bayou. These specimens present the following characters:

Sex.	Head.	Depth.	Snout.	Rings.	Position of dorsal.	No. of dorsal rays.	Location.
Female ..	7+	14	2	17+28	3.5+4	31	Grand Plains Bayou.
Do....	7+	17+	2+	17+33	4 +4	33	Do.
Do....	6.4	14	2	17+30	4 +4	31	Do.
Do....	7+	....	2+	17+31	4 +5	34	Do.
Do....	7	15.85	2	16+34	4 +4	36	Lake Lapourde.
Do....	7.75	16.4	2	17+34	4 +4	33	Do.
Male	8	26	2	17+34	4 +4	33	Do.
Do....	8	28	2+	17+35	4 +4	33	Do.
Do....	7.84	25	2+	17+36?	4 +4	34	Do.
Do....	8	28	2.25	17+36	4 +4	33?	Do.

45. **Aphredoderus sayanus** (Gilliams). *Pirate Perch.* Several specimens from Michelli, 3 from Beaumont, and 1 from Lake Lapourde.
46. **Menidia peninsulæ** (Goode & Bean). Many specimens from Grand Plains Bayou and Lake Lapourde.
47. **Labidesthes sicculus** (Cope). *Skipjack.* Five specimens from Black Bayou and 9 from Michelli.
48. **Mugil cephalus** Linnæus. *Common Mullet.* Common about Baldwin Lodge; runs up the Atchafalaya at least to Morgan City.

49. **Querimana gyrans** Jordan & Gilbert. One taken in Grand Plains Bayou.

50. **Elassoma zonatum** Jordan. *Pigmy Sunfish.* One taken in Lake Lapourde.

51. **Pomoxis annularis** Rafinesque. *Crappie.* Said to occur in Mulatto Bayou, near Sea Glen, Mississippi.

52. **Pomoxis sparoides** (Lacépède). *Calico Bass.* Two small examples from Beaumont and 3 from Michelli.

53. **Centrarchus macropterus** (Lacépède). *Round Sunfish*; *Flier.* Two young examples from Lake Lapourde. Color in alcohol: Body crossed by five broad olive bands separated by very narrow pale ones. Dorsal ocellus very plain.

54. **Chænobryttus gulosus** (Cuvier & Valenciennes). *Warmouth*; "*Goggle-eye.*" Common everywhere; specimens from Grand Plains Bayou, Black Bayou, Lake Lapourde, and Beaumont; reported from Lakes Tasse and Peigneur.

55. **Apomotis symmetricus** (Forbes). Three young from Lake Lapourde, each showing a very distinct dorsal ocellus.

56. **Lepomis miniatus** Jordan. One from Black Bayou and 5 from Lake Lapourde.

57. **Lepomis garmani** Forbes. Eleven specimens from Beaumont and 1 from Michelli, upon which we have the following notes: Head (without flap) 3; depth 2; eye 4; snout 3.5. D. x, 11; A. III, 9; scales 6–38–12, 5 rows on cheek. Teeth sharp; gillrakers very short.

58. **Lepomis pallidus** (Mitchill). *Blue-gill Sunfish.* One from Black Bayou and 6 from Beaumont.

59. **Eupomotis heros** (Baird & Girard). Two specimens obtained at Beaumont.

60. **Micropterus salmoides** (Lacépède). *Large-mouth Black Bass*; "*Green Trout.*" Abundant about Baldwin Lodge and all other waters examined. Specimens from Michelli, Baldwin Lodge, and Beaumont.

61. **Percina caprodes** (Rafinesque). *Log Perch.* One fine specimen from Angelina River, Michelli. Head 4.25; depth 4.84; eye 4.75; snout 3.8. D. XVI–13; A. II, 9; scales 11–89–10; nape well scaled. About 17 dark vertical bars, with shorter ones above lateral line.

62. **Boleosoma camurum** Forbes. *Darter.* One from Lake Lapourde and 7 from Michelli.

63. **Etheostoma jessiæ** (Jordan & Brayton). *Darter* Three from Michelli.

64. **Roccus chrysops** (Rafinesque). *White Bass*; "*Barfish.*" One obtained at Melville; reported from Baldwin Lodge, Lake Tasse, and Lake Peigneur.

65. **Lagodon rhomboides** (Linnæus). *Pinfish*; *Bream.* Specimens from Baldwin Lodge, where it is common.

66. **Archosargus probatocephalus** (Walbaum). *Sheepshead.* Common about Baldwin Lodge and elsewhere on the coast.

67. **Cynoscion nebulosus** (Cuvier & Valenciennes). *Spotted Sea Trout.* One example 8.5 inches long from Lake Borgne.

68. **Sciænops ocellatus** (Linnæus). *Red Drum.* Common about Baldwin Lodge and the mouth of the Atchafalaya River.

69. **Leiostomus xanthurus** Lacépède. *Spot.* Common about Baldwin Lodge, numerous specimens having been obtained there.

70. **Micropogon undulatus** (Linnæus). *Croaker.* Specimens from Baldwin Lodge and Lake Lapourde.

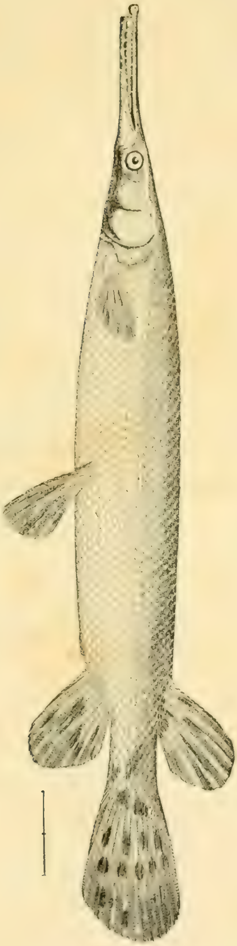
71. **Aplodinotus grunniens** Rafinesque. "*Gaspergou.*" Reported from Neches and Angelina rivers and Lakes Tasse and Peigneur.

72. **Microgobius gulosus** (Girard). *Goby.* Five from Grand Plains Bayou.

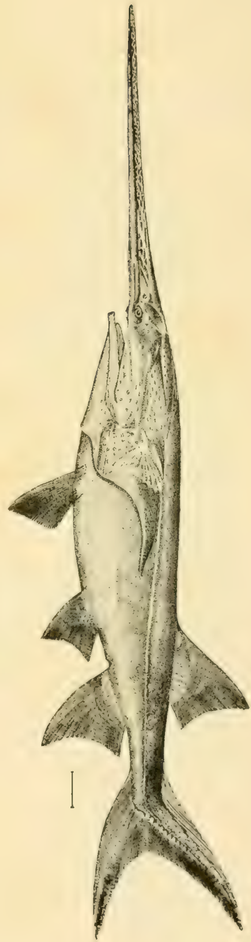
73. **Gobiosoma bosci** (Lacépède). *Goby.* Common; specimens obtained at Baldwin Lodge, Grand Plains Bayou, and Lake Lapourde.

74. **Achirus fasciatus** Lacépède. *Sole.* One small example from Grand Plains Bayou and 4 from Flat Lake, Morgan City.

PLATE 8.

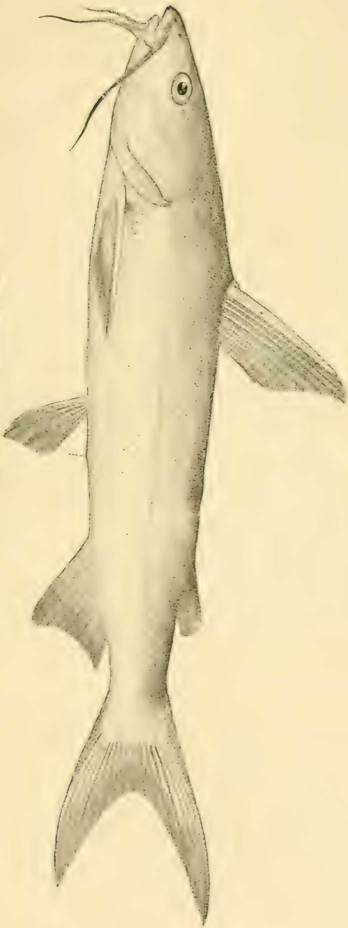


LEPISOSTEUS PLATOSTOMUS Rafinesque *Short-nosed Gar.*

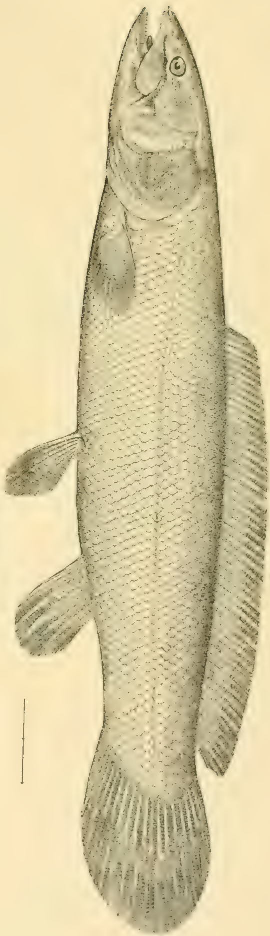


POLYODON SPATHULA (Walbaum). *Spoonbill Cat.*

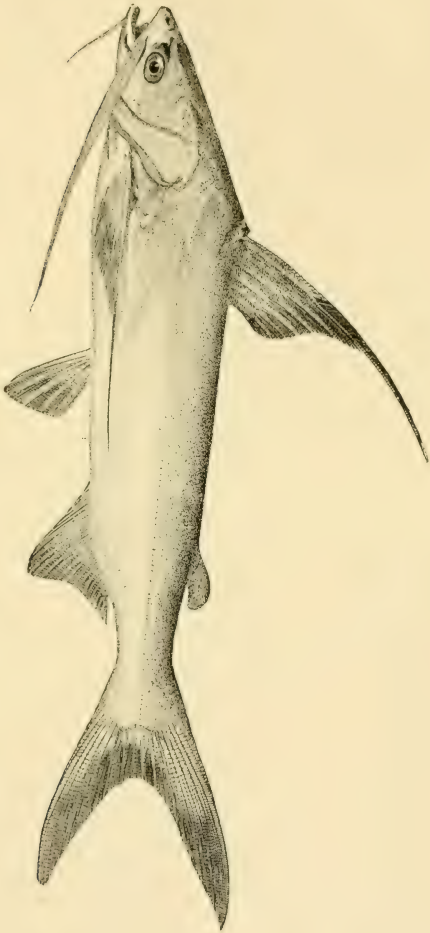
PLATE 9.



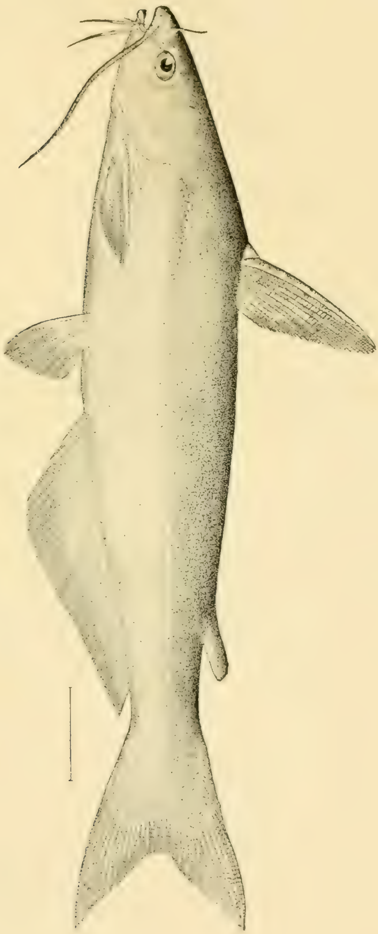
GALEICHTHYS FELIS (Linnæus). *Sea Catfish; "Catfish."*



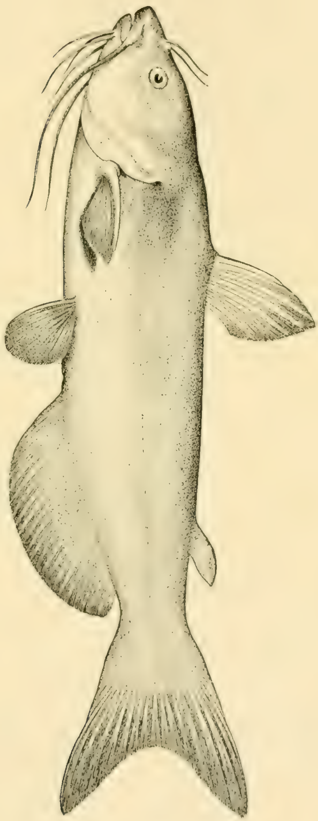
AMIA CALVA Linnæus. *Bowfin; "Grinnel."*



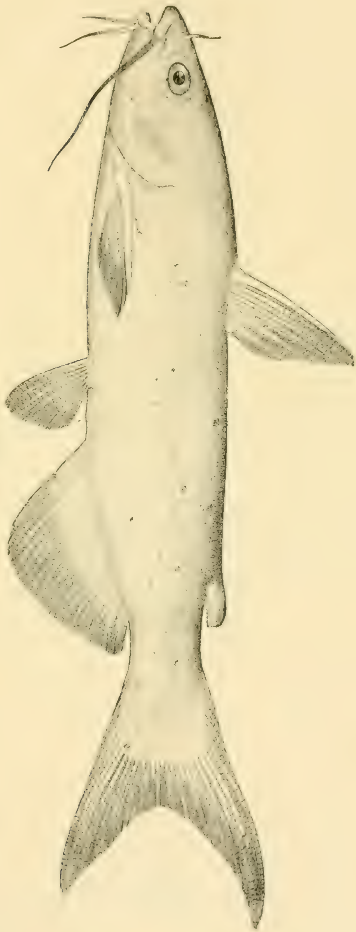
FELICHTHYS MARINUS (Mitchill). *Gaff-topsail; "Catfish."*



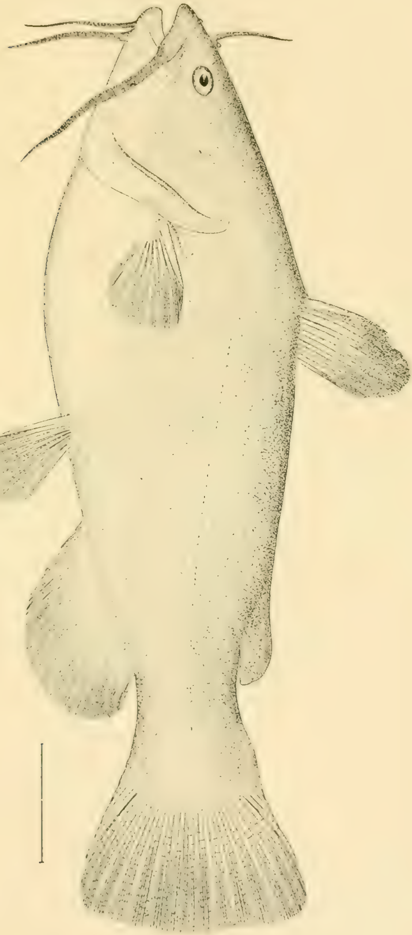
ICTALURUS FURCATUS (LeSueur) *Blue Cat.*



ICTALURUS ANGUILLA Evermann & Kendall. *Eel Cat.*

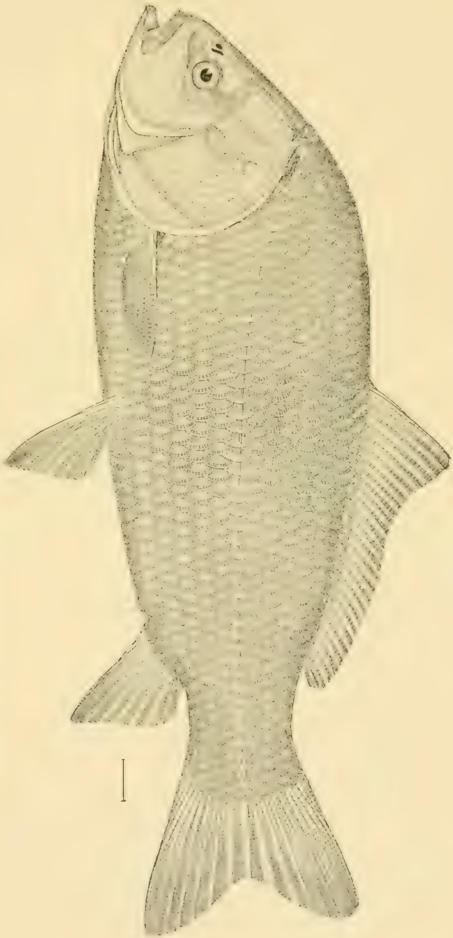


ICTALURUS PUNCTATUS (Rafinesque) *Spotted Cat.*

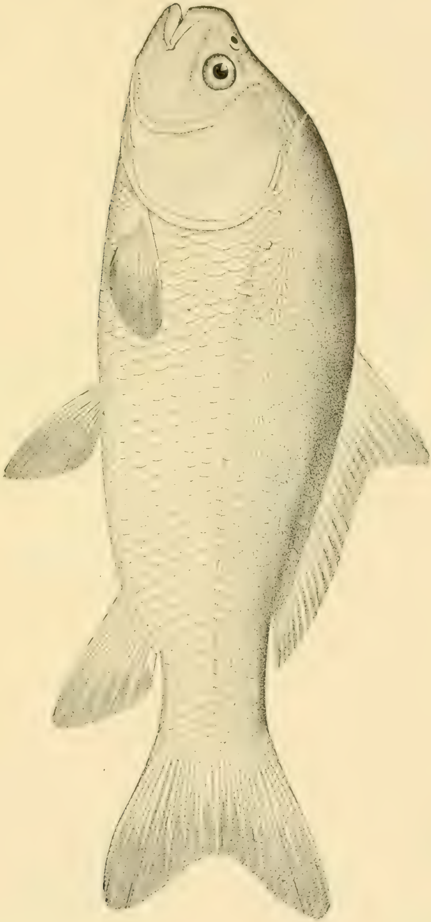


AMEIURUS MELAS (Rafinesque). *Black Bullhead.*

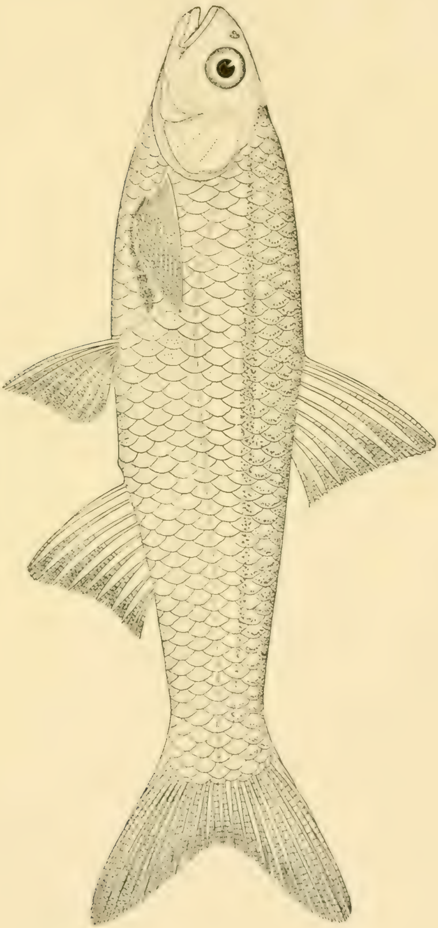
LEPTOPS OLIVARIS (Rafinesque). *Yellow Cat; "Goujon."*



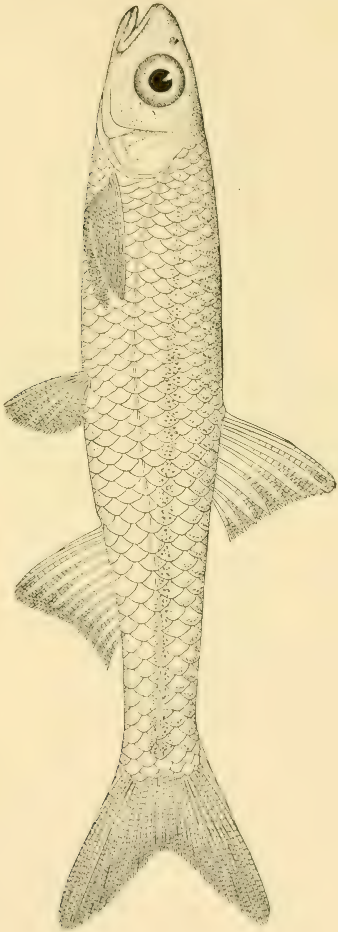
ICTIOBUS CYPRINELLA (Cuvier & Valenciennes). *Common Buffalo-fish; "Gourd-head Buffalo."*



ICTIOBUS BUBALUS (Rafinesque). *Small-mouthed Buffalo; "White Buffalo".*

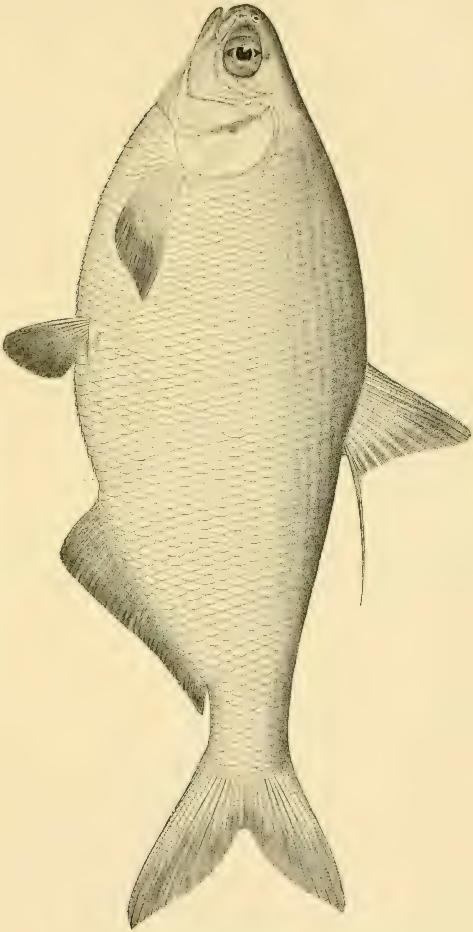


NOTROPIS CHAMBERLAINI Evermann.

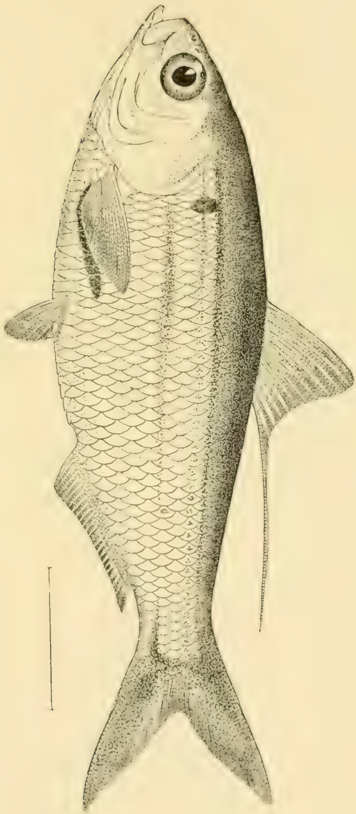


NOTROPIS LOUSIANÆ Evermann.

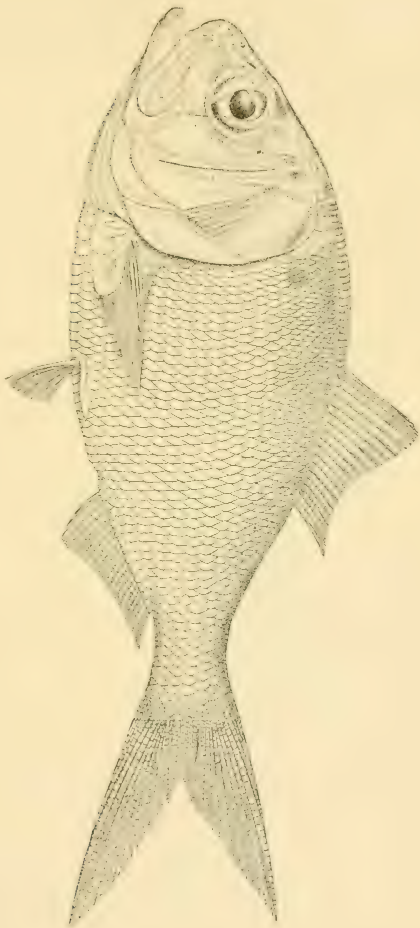
PLATE 20.



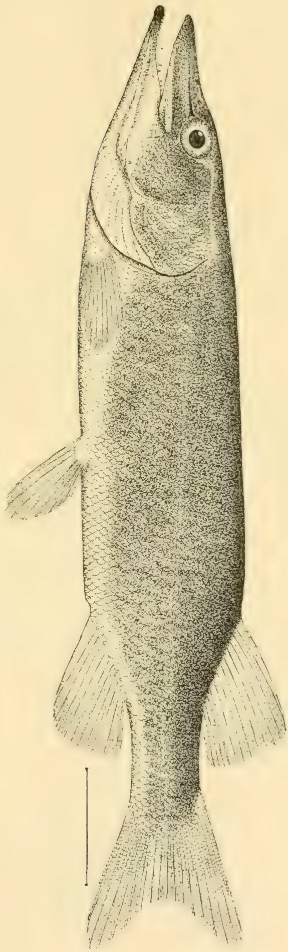
DOROSOMA CEPEDIANUM EXILE Jordan & Gilbert. *Hickory Shad.*



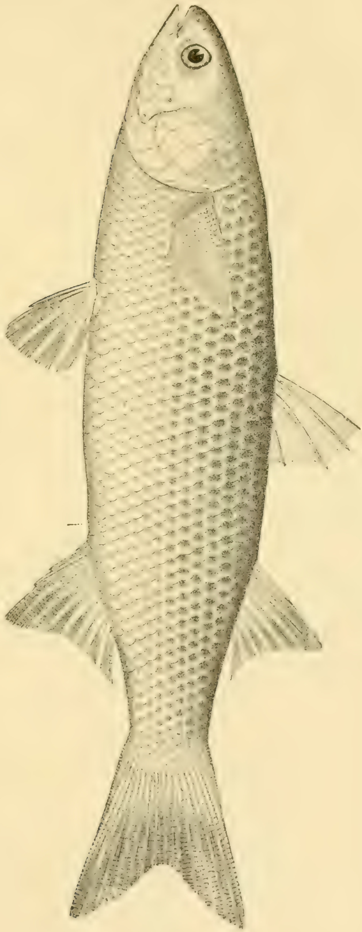
SIGNALOSA ATCHAFALAYÆ Evermann & Kendall.



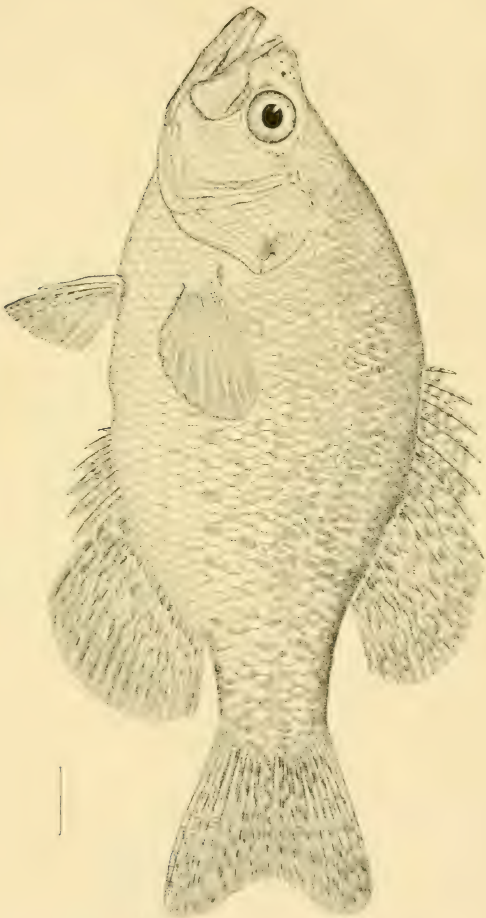
BREVOORTIA TYRANNUS PATRONUS Goode. *Gulf Menhaden.*



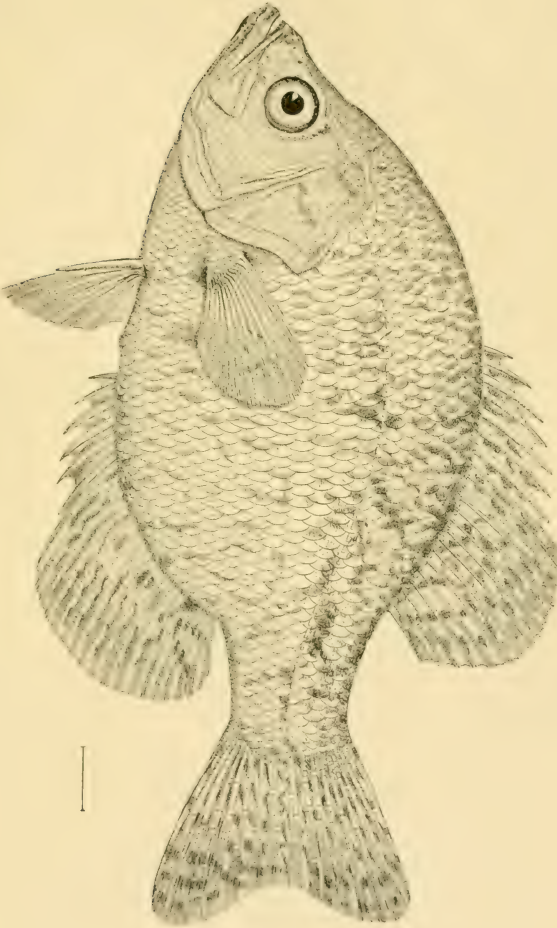
LUCIUS VERMICULATUS (LeSueur). *Little Pickerel.*



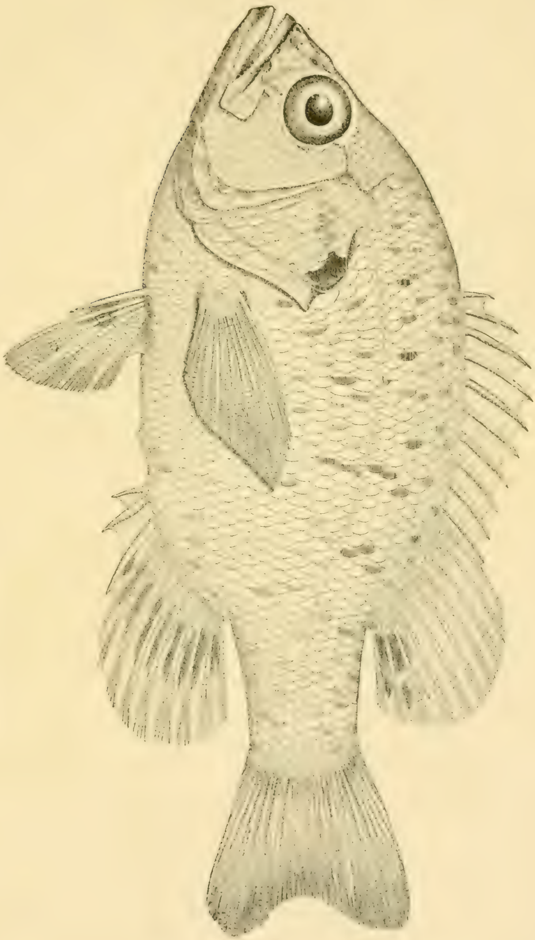
MUGIL CEPHALUS Linnæus. *Common Mullet; Striped Mullet.*



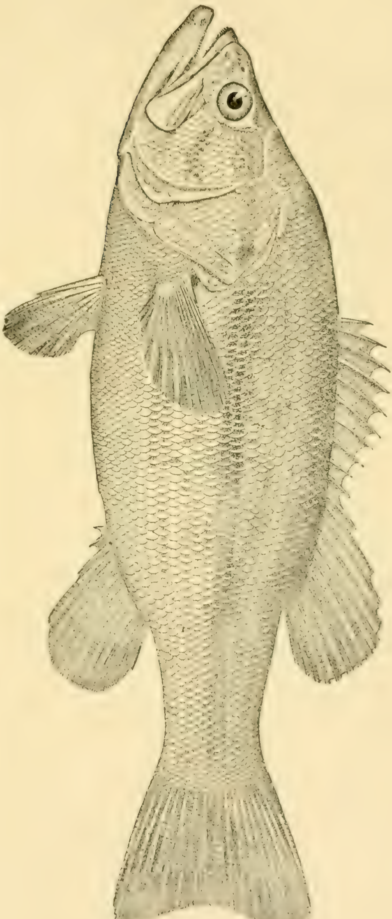
POMOXIS ANNULARIS Rafinesque. *Crappie.*



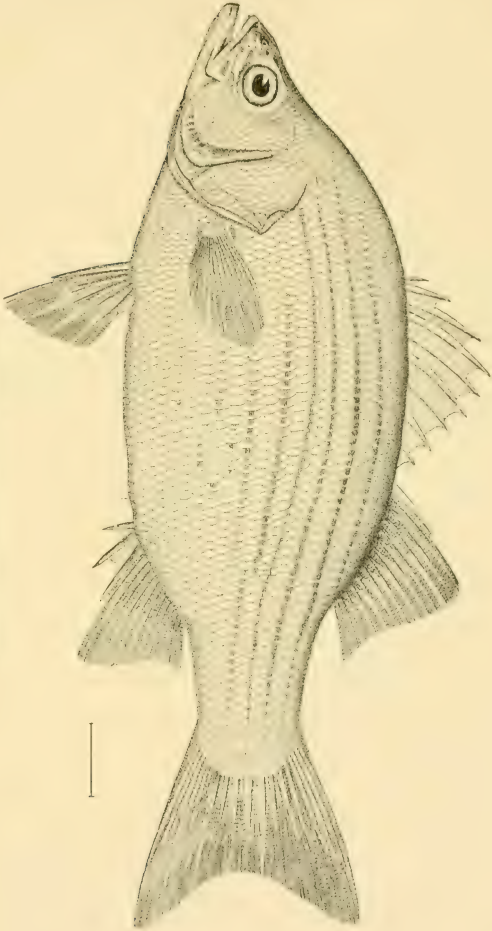
POMOXIS SPAROIDES Lacépède. *Strawberry Bass; Calico Bass.*



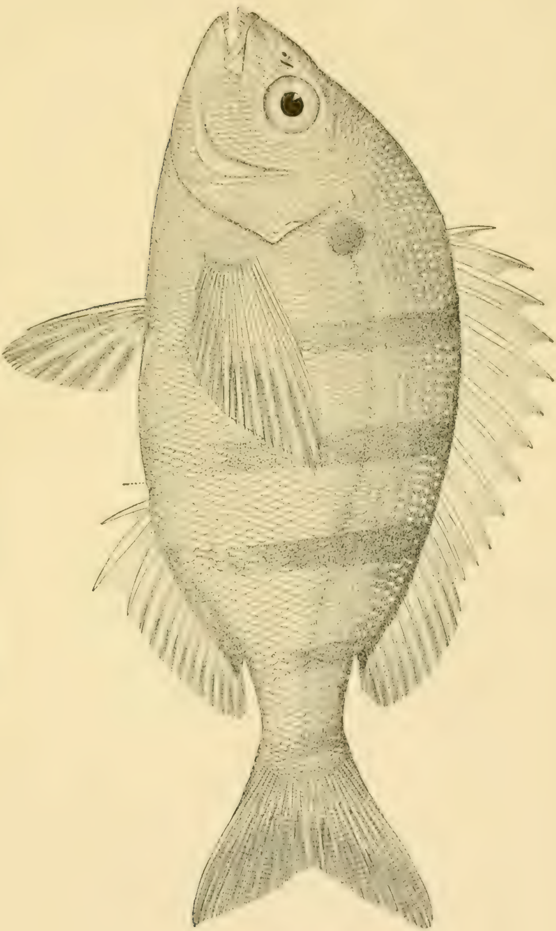
CHÆNOBRYTTUS GULOSUS (Cuvier & Valenciennes). *Warmouth; "Goggle-eye."*



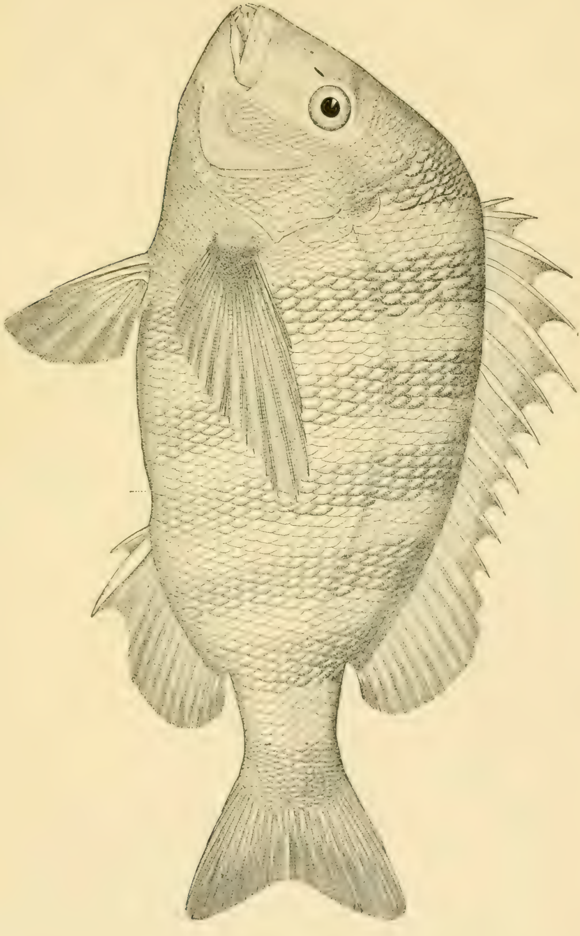
MICROPTERUS SALMOIDES (Lacépède). *Large-mouthed Black Bass; "Trout;" "Green Trout."*



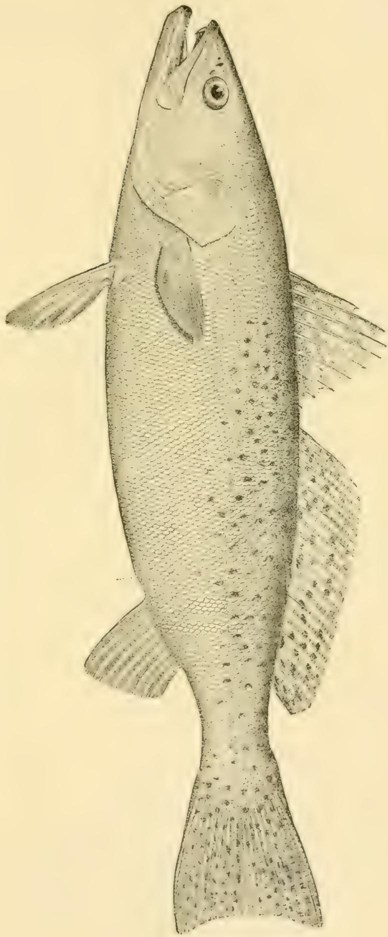
ROCCUS CHRYSOPS (Rafinesque). *White Bass; "Barfish."*



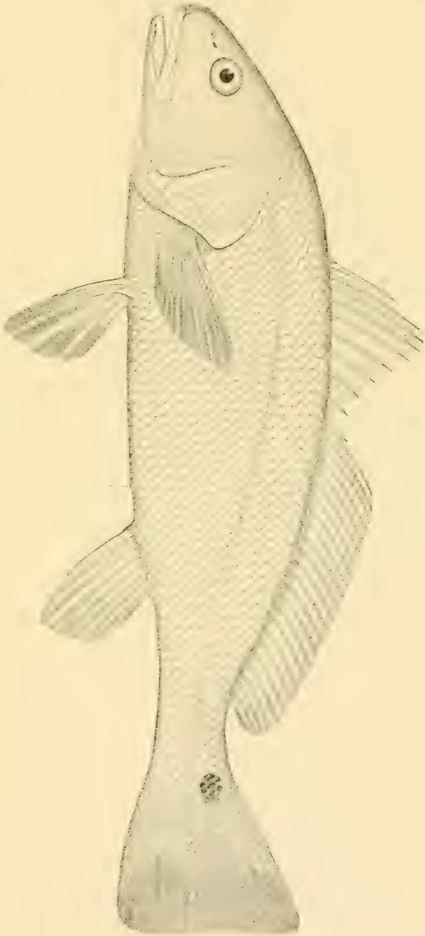
LAGODON RHOMBOIDES (Linnæus). *Sailor's Choice; Bream; Pinfish.*



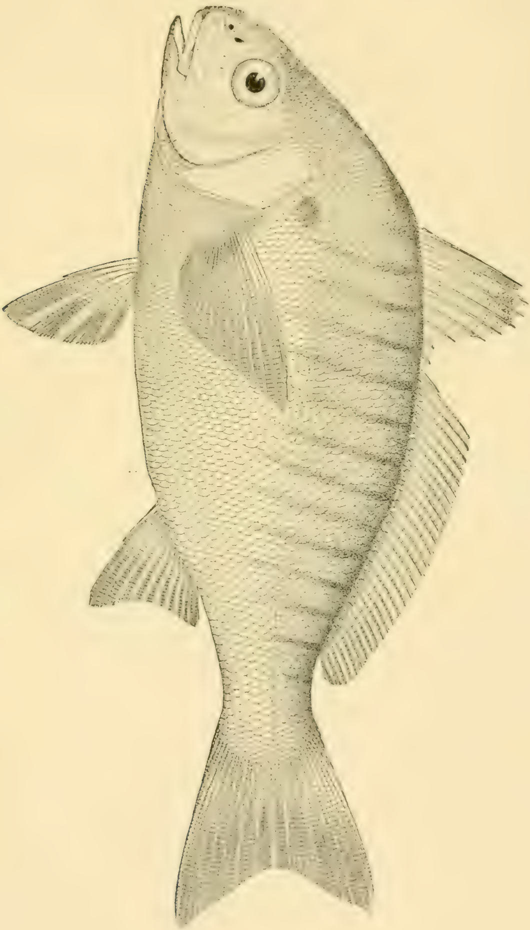
ARCHOSARGUS PROBATOCEPHALUS (Walbaum). *Sheepshead.*



CYNOSCION NEBULOSUS (Cuvier & Valenciennes). *Spotted Squeteague; Spotted Sea Trout.*

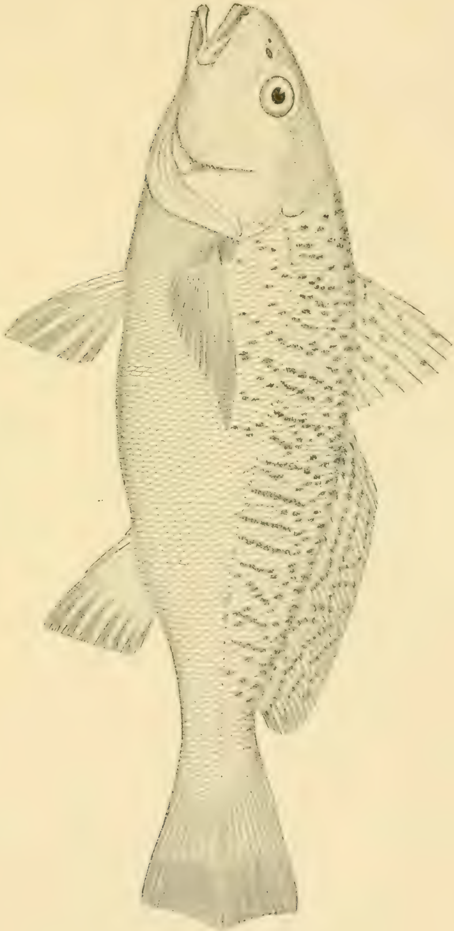


SCIÆNOPS OCELLATUS (Linnæus). *Red Drum; Redfish.*

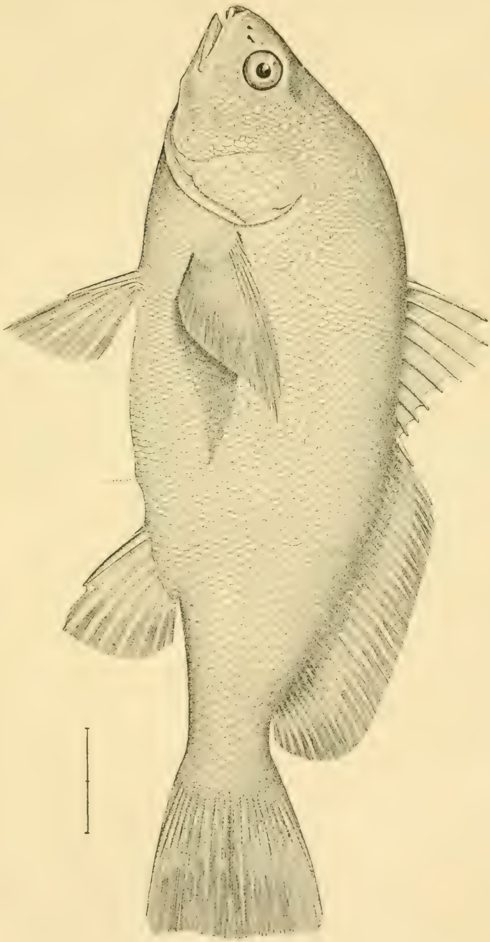


LEIOSTOMUS XANTHURUS Lacépède. *Pinfish*

PLATE 35.



MICROPOGON UNDULATUS (Linnæus). Croaker.



APLODINOTUS GRUNNIENS Rafinesque. *Fresh water Drum; "Gaspergou;" "White Perch.*

PUBLICATIONS

OF THE

UNITED STATES COMMISSION OF FISH AND FISHERIES AVAILABLE FOR DISTRIBUTION ON MARCH 1, 1899.

PUBLICATIONS OF THE UNITED STATES COMMISSION OF FISH AND FISHERIES AVAILABLE FOR DISTRIBUTION ON MARCH 1, 1899.

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XIX	1893	1895	484	35
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PAMPHLET PUBLICATIONS.

Each pamphlet has a serial number, which appears on the left in the accompanying list. The missing numbers are out of print and can not be supplied.

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4. Report of the Commissioner for 1872 and 1873.—A. Inquiry into the decrease of the food-fishes.—B. The propagation of food-fishes in the waters of the United States, by Spencer F. Baird. Report for 1872-73, II, pp. I-CII. 1874.
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290. The salmon fisheries of Columbia River, together with a report upon physical and natural history investigations in the region by C. H. Gilbert and B. W. Evermann, by Marshall McDonald. Bulletin for 1894, XIV, pp. 153-168, plates 13-15. 1894.
292. Notes on fishes collected in Florida in 1892, by James A. Henshall. Bulletin for 1894, XIV, pp. 209-221. 1894.
293. Notes on a reconnaissance of the fisheries of the Pacific coast of the United States in 1894, by Hugh M. Smith. Bulletin for 1894, XIV, pp. 223-288. 1894.
294. Feeding and rearing of fishes, particularly trout, under domestication, by William F. Page. Bulletin for 1894, XIV, pp. 289-314. 1895.
295. Report upon investigations in the Maumee River Basin during the summer of 1893, by Philip H. Kirsch. Bulletin for 1894, XIV, pp. 315-337. 1895.
296. A statistical report on the fisheries of the Middle Atlantic States, by Hugh M. Smith. Bulletin for 1894, XIV, pp. 339-467. 1895.
297. The fishes of the Colorado Basin, by Barton W. Evermann and Cloud. Rutter. Bulletin for 1894, XIV, 473-486. 1895.
297. A list of species of fishes known from the vicinity of Neosho, Mo., by Barton W. Evermann and W. C. Kendall. Bulletin for 1894, XIV, pp. 469-472. 1895.
298. Report of the Commissioner for the fiscal year ending June 30, 1893, including the reports on divisions of fish-culture, scientific inquiry, and fisheries, by Marshall McDonald. Report for 1893, XIX, pp. 1-138. 1896.
300. The American lobster. A study of its habits and development, by Francis Hobart Herrick. Bulletin for 1895, XV, pp. 1-252, plates A-J and 1-54. 1896.
301. A preliminary report upon salmon investigations in Idaho in 1894, by Barton W. Evermann. Bulletin for 1895, XV, pp. 253-284. 1896.
302. Notes on an investigation of the menhaden fishery in 1894, with special reference to the food-fishes taken, by Hugh M. Smith. Bulletin for 1895, XV, pp. 285-302. 1896.
303. The fishes of the Neuse River Basin, by Barton W. Evermann and Ulysses O. Cox. Bulletin for 1895, XV, pp. 303-310. 1896.
304. Notes on intensive pond culture at Sandfort, by S. Jaffé. Bulletin for 1895, XV, pp. 311-316. 1896.
304. Notes on the rearing of yearling trout at Sandfort, by S. Jaffé. Bulletin for 1895, XV, pp, 317-319. 1896.
304. Fish-cultural methods at the Agricultural School at Freising. Anonymous. Bulletin for 1895, XV, pp. 320-321, plate 55. 1896.
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305. Report on a reconnaissance of the oyster-beds of Mobile Bay and Mississippi Sound, Alabama, by Homer P. Ritter. Bulletin for 1895, XV, pp. 325-339, plates 56-63. 1896.
306. A list of fishes and mollusks collected in Arkansas and Indian Territory in 1894, by Seth Eugene Meek. Bulletin for 1895, XV, pp. 341-349. 1896.
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309. A review of the history and results of the attempt to acclimatize fish and other water animals in the Pacific States, by Hugh M. Smith. Bulletin for 1895, XV, pp. 379-472, plates 73-83. 1896.
310. Report upon the work of the U. S. Fish Commission steamer *Albatross* for the year ending June 30, 1893, by Z. L. Tanner. Report for 1893, XIX, pp. 305-341, plates 15-18. 1896.
311. Report of the representative of the U. S. Fish Commission at the World's Columbian Exposition, by Tarleton H. Bean. Report for 1894, XX, pp. 177-196, plates 1-5. 1896.

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312. Report upon ichthyological investigations in western Minnesota and eastern North Dakota, by Albert J. Woolman. Report for 1893, XIX, pp. 343–373, plate 19. 1896.
313. The food of the oyster, clam, and ribbed mussel, by John P. Lotsy. Report for 1893, XIX, pp. 375–386 (including 4 figs.). 1896.
314. Establishment of stations for the propagation of salmon on the Pacific Coast, by John J. Brice. Report for 1893, XIX, pp. 387–392. 1896.
315. Report of the Commissioner for the fiscal year ending June 30, 1894, including the reports on the divisions of fish-culture, scientific inquiry, and fisheries, by Marshall McDonald. Report for 1894, XX, pp. 1–175. 1896.
316. The Russian fur-seal islands, by Leonard Stejneger. Bulletin for 1896, XVI, pp. 1–148, plates 1–66. 1896.
317. Remarks on the movements and breeding grounds of the fur-seal, based on observations made while on the United States naval patrol of Bering Sea in 1894, by John J. Brice. Report for 1894, XX, pp. 573–577. 1896.
318. A report upon salmon investigations in the head waters of the Columbia River, in the State of Idaho, in 1895; together with notes upon the fishes observed in that State in 1894 and 1895, by Barton W. Evermann. Bulletin for 1896, XVI, pp. 149–202, plates 67–72. 1896.
319. The artificial propagation of the rainbow trout, by George A. Seagle. Bulletin for 1896, XVI, pp. 237–256, plates 88–94. 1896.
320. The artificial propagation of salmon on the Pacific Coast of the United States, with notes on the natural history of the quinnat salmon, by Livingston Stone. Bulletin for 1896, XVI, pp. 203–235, plates 73–87. 1896.
321. Report upon the operations of the U. S. Fish Commission steamer *Albatross* for the year ending June 30, 1894, by Z. L. Tanner and F. J. Drake. Report for 1894, XX, pp. 197–278, plates 6–8. 1896.
322. Description of a closing tow net for submarine use at all depths, by C. H. Townsend. Report for 1894, XX, pp. 279–282, plates 9, 10. 1896.
323. The whitefishes of North America, by Barton W. Evermann and Hugh M. Smith. Report for 1894, XX, pp. 283–324, plates 11–28. 1896.
324. A report upon the fishes of the Missouri River Basin, by Barton W. Evermann and Ulysses O. Cox. Report for 1894, XX, pp. 325–429. 1896.
325. A review of the foreign fishery trade of the United States, by Charles H. Stevenson. Report for 1894, XX, pp. 431–571. 1896.
326. The ichthyological collections of the U. S. Fish Commission steamer *Albatross* during the years 1890 and 1891, by Charles H. Gilbert. Report for 1893, XIX, pp. 393–476, plates 20–35. 1896.
327. An annotated catalogue of the fishes known from the State of Vermont, by Barton W. Evermann and W. C. Kendall. Report for 1894, XX, pp. 579–604.
328. A report upon the fishes of southwestern Minnesota, by Ulysses O. Cox. Report for 1894, XX, pp. 605–616. 1896.
329. List of publications of the U. S. Commission of Fish and Fisheries from its establishment, in 1871, to February, 1896, by Charles W. Scudder. Report for 1894, XX, pp. 617–706. 1896.
330. Deep-sea explorations: A general description of the steamer *Albatross*, her appliances and methods, by Z. L. Tanner. Bulletin for 1896, XVI, pp. 257–428 (including 76 figs.), pls. I–XL. 1897.
331. Report of the Commissioner for the fiscal year ending June 30, 1895, including the reports on the divisions of fish-culture, scientific inquiry, and fisheries, by Marshall McDonald. Report for 1895, XXI, pp. 1–123. 1896.
332. Report upon the investigations of the U. S. Fish Commission steamer *Albatross* for the year ending June 30, 1895 (abstract), by F. J. Drake. Report for 1895, XXI, pp. 125–168. 1896.
333. Notes on Biscayne Bay, Florida, with reference to its adaptability as the site of a marine hatching and experiment station, by Hugh M. Smith. Report for 1895, XXI, pp. 169–191. 1896.
334. The transplanting of eastern oysters to Willapa Bay, Washington, with notes on the native oyster industry, by C. H. Townsend. Report for 1895, XXI, pp. 193–202, plate 1. 1896.
335. Description of a new species of shad (*Alosa alabamæ*) from Alabama, by Barton W. Evermann. Report for 1895, XXI, pp. 203–205. 1896.
336. A check-list of the fishes and fish-like vertebrates of North and Middle America, by David Starr Jordan and Barton Warren Evermann. Report for 1895, XXI, pp. 207–584. 1896.
337. Report of the Commissioner for the fiscal year ending June 30, 1896, including the reports on divisions of fish-culture, scientific inquiry, and fisheries, by John J. Brice. Report for 1896, XXII, pp. 1–145, plates 1–10. 1897.

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338. Report of the representative of the U. S. Fish Commission at the Cotton States and International Exposition at Atlanta, Ga., in 1895, by W. de C. Ravenel. Report for 1896, XXII, pp. 147–167 (including 3 figs.), plates 11–21. 1897.
339. Notes on the extension of the recorded range of certain fishes of the United States Coast, by Hugh M. Smith and William C. Kendall. Report for 1896, XXII, pp. 169–176. 1897.
340. Notes on the food of four species of the cod family, by William C. Kendall. Report for 1896, XXII, pp. 177–186. 1897.
341. The fisheries of Indian River, Florida, by John J. Brice et al. Report for 1896, XXII, pp. 223–262, plates 22–60. 1897.
342. Report on the fish and fisheries of the coastal waters of Florida, by John J. Brice. Report for 1896, XXII, pp. 263–342. 1897.
343. Report of a survey of the oyster regions of St. Vincent Sound, Apalachicola Bay, and St. George Sound, Florida, by Franklin Swift. Report for 1896, XXII, pp. 187–221, plate 21. 1897.
344. Report of the Commissioner for the fiscal year ending June 30, 1897, including the reports on divisions of fish-culture, scientific inquiry, and fisheries, by John J. Brice. Report for 1897, XXIII, pp. I–CLXXI. 1898.
346. Artificial propagation of the Atlantic salmon, rainbow trout, and brook trout. Report for 1897, XXIII, pp. 27–101 (including 14 figures), plates 12–20. 1897.
347. Artificial propagation of the black bass, crappies, and rock bass. Report for 1897, XXIII, pp. 159–177 (including 2 figures), plates 43–49. 1897.
348. Notes on the edible frogs of the United States and their artificial propagation, by F. M. Chamberlain. Report for 1897, XXIII, pp. 249–261 (including 6 figures). 1897.
349. Oysters and methods of oyster-culture, with notes on clam-culture, by H. F. Moore. Report for 1897, XXIII, pp. 263–340 (including 6 figures), plates I–XVIII. 1897.
351. The fishes of the Klamath River Basin, by Charles H. Gilbert. Bulletin for 1897, XVII, pp. 1–13 (including 6 figures). 1898.
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355. Report of observations made on board the U. S. Fish Commission steamer *Albatross* during the year ending June 30, 1896. Report for 1896, XXII, pp. 357–386. 1897.
356. Observations upon the herring and herring fisheries of the northeast coast, with special reference to the vicinity of Passamaquoddy Bay, by H. F. Moore, Ph. D. Report for 1896, XXII, pp. 387–442, plates 60–62. 1897.
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358. Descriptions of new or little-known genera and species of fishes from the United States, by Barton W. Evermann and William C. Kendall. Bulletin for 1897, XVII, pp. 125–133, plates 6–9. 1898.
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361. Statistics of the fisheries of the interior waters of the United States, by Hugh M. Smith. Report for 1896, XXII, pp. 489–574. 1898.
362. Notes on the fisheries of the Pacific coast in 1895, by William A. Wilcox. Report for 1896, XXII, pp. 575–659. 1898.
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366. The importance of extended scientific investigation, by H. C. Bumpus. Bulletin for 1897, XVII, pp. 177–180. 1898.
367. The utility of a biological station on the Florida coast in its relations to the commercial fisheries, by Seth E. Meek. Bulletin for 1897, XVII, pp. 181–183. 1898.
368. Establishment of a biological station on the Gulf coast, by W. Edgar Taylor. Bulletin for 1897, XVII, pp. 185–188. 1898.

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369. Some notes on American shipworms, by Charles P. Sigerfoos. Bulletin for 1897, XVII, pp. 189–191. 1898.
370. An economical consideration of fish parasites, by Edwin Linton. Bulletin for 1897, XVII, pp. 193–199. 1898.
371. The fish fauna of Florida, by B. W. Evermann. Bulletin for 1897, XVII, pp. 201–208. 1898.
372. The lampreys of central New York, by H. A. Surface. Bulletin for 1897, XVII, pp. 209–215, plates 10 and 11. 1898.
373. The protection of the lobster fishery, by Francis H. Herrick. Bulletin for 1897, XVII, pp. 217–224. 1898.
374. The Florida commercial sponges, by Hugh M. Smith. Bulletin for 1897, XVII, pp. 225–240, plates 12–31. 1898.
375. On the feasibility of raising sponges from the egg, by H. V. Wilson. Bulletin for 1897, XVII, pp. 241–245. 1898.
376. The Hudson River as a salmon stream, by A. Nelson Cheney. Bulletin for 1897, XVII, pp. 247–251. 1898.
377. A plea for the development and protection of Florida fish and fisheries, by James A. Henshall. Bulletin for 1897, XVII, pp. 253–255. 1898.
378. International protection for the denizens of the sea and waterways, by Bushrod W. James. Bulletin for 1897, XVII, pp. 257–263. 1898.
379. The restricted inland range of shad due to artificial obstructions, and its effect upon natural reproduction, by Charles H. Stevenson. Bulletin for 1897, XVII, pp. 265–271. 1898.
380. The green turtle and the possibilities of its protection and consequent increase on the Florida coast, by Ralph M. Munroe. Bulletin for 1897, XVII, pp. 273–274. 1898.
381. Some factors in the oyster problem, by H. F. Moore. Bulletin for 1897, XVII, pp. 275–284. 1898.
382. The oyster grounds of the west Florida coast; their extent, condition, and peculiarities, by Franklin Swift. Bulletin for 1897, XVII, pp. 285–287. 1898.
383. The oyster and oyster beds of Florida, by John G. Ruge. Bulletin for 1897, XVII, pp. 289–296. 1898.
384. The Louisiana oyster industry, by F. C. Zacharie. Bulletin for 1897, XVII, pp. 297–304. 1898.
385. The oyster bars of the west coast of Florida, their depletion and restoration, by H. A. Smeltz. Bulletin for 1897, XVII, pp. 305–308. 1898.
386. Notes on the fishing industry of eastern Florida, by John Y. Detwiler. Bulletin for 1897, XVII, pp. 309–312. 1898.
387. Oysters and oyster culture in Texas, by I. P. Kibbe. Bulletin for 1897, XVII, pp. 313–314. 1898.
388. The methods, limitations, and results of whitefish culture in Lake Erie, by J. J. Stranahan. Bulletin for 1897, XVII, pp. 315–319. 1898.
389. A brief history of the gathering of fresh-water pearls in the United States, by George F. Kunz. Bulletin for 1897, XVII, pp. 321–330. 1898.
390. The red-snapper fisheries; their past, present, and future, by Andrew F. Warren. Bulletin for 1897, XVII, pp. 331–335. 1898.
391. Some brief reminiscences of the early days of fish-culture in the United States, by Livingston Stone. Bulletin for 1897, XVII, pp. 337–343. 1898.
392. The relations between State fish commissions and commercial fishermen, by W. E. Meehan. Bulletin for 1897, XVII, pp. 345–348. 1898.
393. Possibilities for an increased development of Florida's fishery resources, by John N. Cobb. Bulletin for 1897, XVII, pp. 349–351. 1898.
394. The utility and methods of mackerel propagation, by J. Percy Moore. Bulletin for 1897, XVII, pp. 353–361. 1898.
395. The large-mouthed black bass in Utah, by John Sharp. Bulletin for 1897, XVII, pp. 363–368. 1898.
396. Florida fur farming, by J. M. Willson, jr. Bulletin for 1897, XVII, pp. 369–371. 1898.
397. The fresh-water pearls and pearl fisheries of the United States, by George F. Kunz. Bulletin for 1897, XVII, pp. 373–426, plates I–XXII.
398. Report of the Commissioner for the fiscal year ending June 30, 1898, including the reports on divisions of fish culture, scientific inquiry, and fisheries, by George M. Bowers. Report for 1898, XXIV, pp. I–CLXXXI, plates I–XXI. 1899.
399. Report on mackerel investigations in 1897, by J. Percy Moore. Report for 1898, XXIV, pp. 1–22. 1899.
400. Report on fishes obtained by the steamer *Albatross* in the vicinity of Santa Catalina Island and Monterey Bay, by Charles H. Gilbert. Report for 1898, XXIV, pp. 23–29, plates 1 and 2. 1899.

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401. Notes on the extent and condition of the alewife fisheries of the United States in 1896, by Hugh M. Smith. Report for 1898, XXIV, pp. 31–43. 1899.
402. Report on the oyster beds of Louisiana, by H. F. Moore. Report for 1898, XXIV, pp. 45–100, plate 3. 1899.
403. The shad fisheries of the Atlantic coast of the United States, by Charles H. Stevenson. Report for 1898, XXIV, pp. 101–269. 1899.
404. List of fishes collected at the Revillagigedo Archipelago and neighboring islands, by David Starr Jordan and Richard Crittenden McGregor. Report for 1898, XXIV, pp. 273–284, plates 4–7. 1899.
405. Report on investigations by the U. S. Fish Commission in Mississippi, Louisiana, and Texas in 1897, by Barton Warren Evermann. Report for 1898, XXIV, pp. 285–310, plates 8–36. 1899.
406. List of publications of the U. S. Commission of Fish and Fisheries available for distribution on March 1, 1899. Report for 1898, XXIV, pp. 311–327. 1899.
407. Report upon exhibit of the United States Fish Commission at the Tennessee Centennial Exposition in 1897, by W. de C. Ravenel. Report for 1898, XXIV, pp. 329–339, plate 37. 1899.

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REPORT

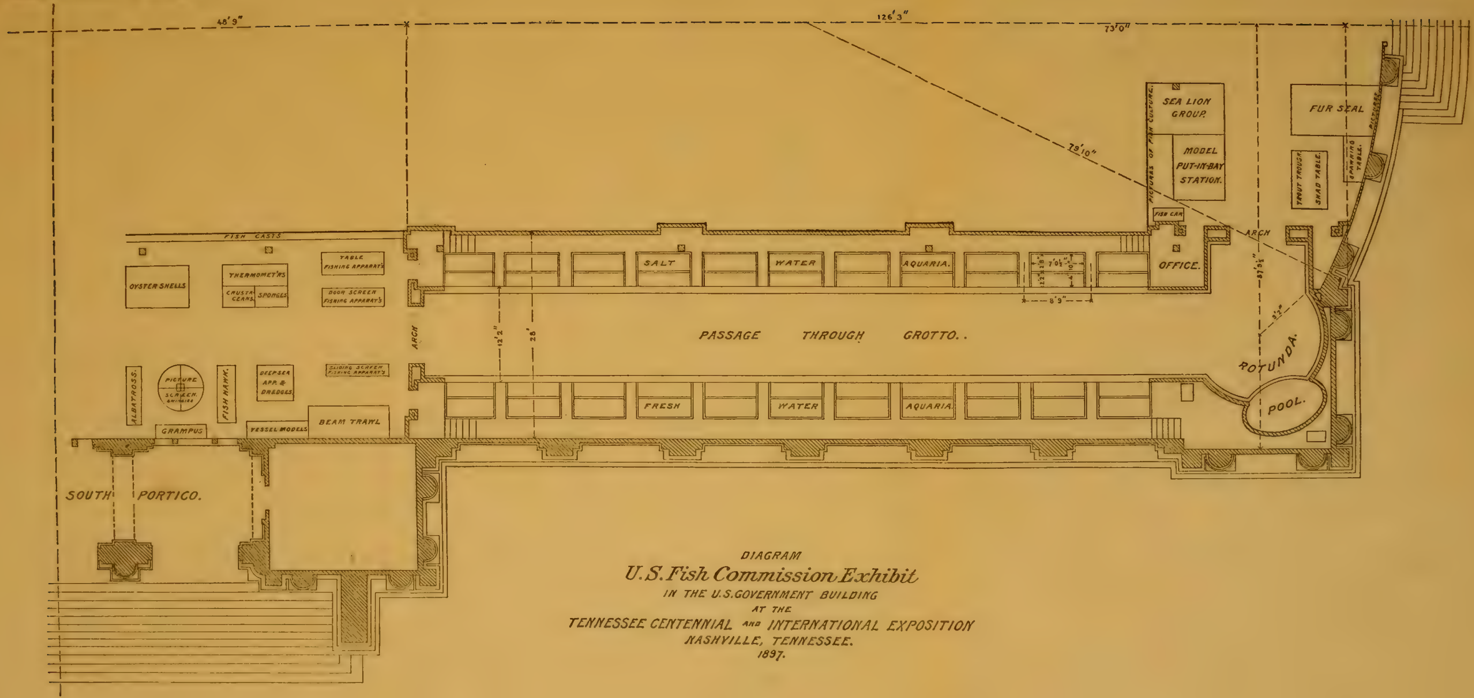
UPON THE

EXHIBIT OF THE UNITED STATES COMMISSION OF FISH AND FISHERIES

AT THE

TENNESSEE CENTENNIAL EXPOSITION IN 1897.

By W. de C. RAVENEL,
Representative of the United States Fish Commission.



DIAGRAM

U.S. Fish Commission Exhibit

IN THE U.S. GOVERNMENT BUILDING

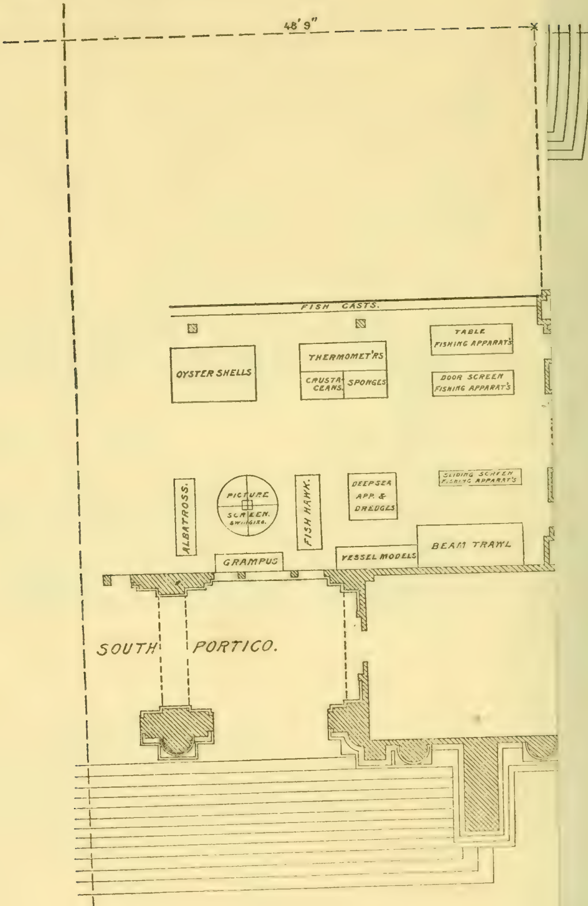
AT THE

TENNESSEE CENTENNIAL AND INTERNATIONAL EXPOSITION

NASHVILLE, TENNESSEE.

1897.

E 37.


48' 9"
FISH CASTS.
TABLE FISHING APPARAT'S
OYSTER SHELLS
THERMOMET'RS
CRUSTACEANS.
SPONGES
DOOR SCREEN FISHING APPARAT'S
SLIDING SCREEN FISHING APPARAT'S
ALBATROSS.
PICTURE SCREEN.
FISH HAWK.
DEEPSEA APP. & DREDGES
BEAM TRAWL
GRAMPUS
VESSEL MODELS
SOUTH PORTICO.

REPORT UPON THE EXHIBIT OF THE UNITED STATES COMMISSION OF FISH AND FISHERIES AT THE TENNESSEE CENTENNIAL EXPOSITION IN 1897.

By W. de C. Ravenel,
Representative of the United States Fish Commission.

Under the act of Congress approved December 22, 1896, providing for the participation of the United States Fish Commission in the Tennessee Centennial Exposition at Nashville, Tenn., Mr. W. de C. Ravenel, assistant in charge of the Division of Fish-culture, was appointed as the representative of the Commission on the Government Board of Management.

The plan, as approved by the Commissioner, was as follows:

1. Scientific investigations of the Commission, to be illustrated by models of the vessels belonging to the United States Fish Commission, with full-sized forms of the apparatus used, and by illustrations showing the work of these vessels; by collections of marine animals, and by casts of colored fishes, drawn from life; and by collections of sponges, corals, oysters, and other shellfish.

2. Fish-cultural operations, to be shown by models and photographs of important hatching stations; models and full-sized specimens of apparatus used in the collection, transportation, and hatching of eggs, and the distribution of fish; charts showing the work done by the Commission since its organization, and results with reference to special fisheries; also, by the hatching of the eggs of the various species of the salmonidæ and shad; also, an aquarium for showing the important food and game fishes reared by the United States Fish Commission at its various stations, together with the important fishes of the Ohio Valley, and the principal species taken in the South Atlantic Ocean and Gulf of Mexico.

3. Methods and statistics of the fisheries, to be illustrated by models of vessels used in the important fisheries of the South Atlantic and Gulf States; models of boats and the common forms of fishing apparatus, such as pounds, weirs, seines, trawl lines, hand lines, etc.; also, oyster and clam rakes, tongs, hooks for sponges, etc.; besides illustrations of various fisheries by means of photographs, oil paintings, and etchings.

As soon as possible after the organization of the board and the allotment of space and funds, preparations were commenced for the construction of the aquarium and the collection of the material comprising the exhibit. The Commission was allotted $15,500 and 5,000 square feet of space located in the southeast corner of the building. The space was L-shaped and extended from the main aisle at the east

entrance to the intersecting main aisle at the south entrance. By May 17, 1897, when the Government building was opened to the public, the exhibit was installed and ready for inspection, the aquarium stocked with both fresh-water and salt-water fishes, and the hatchery illustrating the methods employed in the hatching of the eggs of the shad and the trout, was in operation.

The accompanying diagram shows the arrangement of the exhibits and the amount of space occupied by the various forms. Of the total allotment of 5,000 feet the aquarium occupied 3,360 feet; the exhibits illustrating fish-cultural work, scientific inquiry, and the methods and statistics of the fisheries, the remaining 1,640.

The articles exhibited are comprised in the following list:

Scientific Inquiry Section.

1. Exploring vessels:
   - Models: Steamer *Albatross*, steamer *Fish Hawk*.
   - Illustrations: Forward deck of steamer *Albatross*. U. S. Fish Commission steamer *Albatross*.
2. Collecting apparatus:
   - Seines and nets: Two Baird seines, 50 and 150 feet long. One herring seine. One herring gill net. Two minnow seines. Two small seines. Two beam trawls, one large (double) and one small model. Two small gauze towing nets.
   - Dredges: One naturalist's boat dredge. One naturalist's deep-sea dredge. Two surface tow nets. One dip net. One Chester rake dredge (two nets). Two oyster dredges.
   - Tangles: One tangle.
3. Accessories for dredging and trawling:
   - Sounding wire: One piece of sounding wire (large size). One piece of sounding wire (common size). Three splices in sounding wire. Two splices in dredge rope.
4. Apparatus for preserving collections:
   - One tank box containing one 16-gallon copper tank for storage and transportation of natural-history specimens.
   - One tank box containing one 8-gallon and two 4-gallon copper tanks for storage and transportation of natural-history specimens.
   - Five jars, assorted sizes.
   - Seven glass bottles with cork stoppers, assorted sizes.
   - Eleven homeopathic vials with rubber stoppers, assorted sizes.
   - Four glass dishes, assorted sizes.
   - Three German-silver naturalist's forceps.
5. Apparatus for deep-sea sounding:
   - One Tanner deep-sea sounding machine, complete with Sigsbee sounder (shot attached) and deep-sea thermometer.
6. Apparatus for physical observations:
   - Thermometers and accessories:
     - Three deck thermometers.
     - One Miller-Casella deep-sea thermometer.
     - One Baird protected thermometer.
     - One Negretti & Zambra deep-sea thermometer.
     - Three wooden cases for deep-sea thermometers (experimental forms).
     - One metal frame for holding deep-sea thermometer (Negretti & Zambra case).
     - Eleven brass cases (experimental forms) for deep-sea thermometers with attachments.
     - One Magnaghi case for deep-sea thermometer.
     - Two Tanner improved metal cases (sixth form), ordinary size, for deep-sea thermometers.
     - One water bottle for deep-sea investigations.
     - One reading glass for Negretti & Zambra thermometer.
     - One set of Hilgard salinometers, with cup and thermometer.
     - One magnet.
7. Results of explorations:
   - Collections (marine animals, dry):
   - (1) Crustaceans:
     - One lobster (*Homarus americanus*).
     - One crab (*Echinocerus setimanus*).

7. Results of explorations—Continued.

(1) Crustaceans—Continued.

One crab (*Echinocerus foraminatus*).
One deep-sea crab (*Geryon quinquedens*).
One common edible crab of the Pacific coast (*Cancer magister*).
One crab (*Mithrax hispidus*).
Three crabs *Pitho anisodon* (young).
One crab *Pitho anisodon* (adult).
Two mantis shrimp (*Squilla empusa*).
One box-crab (*Calappa flammea*).
One great spider-crab (*Lithodes maia*).
One crayfish nest, or chimney.
One spider-crab (*Libinia emarginata*).

(2) Sponges: Sheepswool, velvet, yellow, glove, and grass.

(3) American ornamental corals:

One piece of star coral (*Porites*).
One piece of coral (*Oculina diffusa*).
Two pieces of fungus coral (*Agaricia agaricites*).
One piece of brain coral (*Manicina areolata*).
One piece of coral (*Mussa*).
One piece of star coral (*Orbicella*).

(4) Mollusks, oyster and other shells:

Oyster spat 2 to 3 weeks old; 3 to 4 weeks old; 1 to 2 months old; 2 to 3 months old; 2 to 3 months old, hard bottom; 2 months old, soft bottom.
Oysters 1 year old, hard bottom; 2 years old, hard bottom; 3 years old, hard bottom; 4 years old, hard bottom; 1 year old, soft bottom; 2 years old, soft bottom; 3 years old, soft bottom; 4 years old, soft bottom; 5 years old, soft bottom; 5 years old, hard bottom; 6 years old, hard bottom; 6 years old, soft bottom; large, mud bottom; large, mud bottom.
Oysters, large, 16 years old, soft bottom; large, 12 years old, hard bottom.
Blue Point oysters.
Oyster shells, greatly thickened, due to stunted growth at margin.
Glenwood oysters; Shinnecock Bay oysters; Rockaway oysters; Shrewsbury oysters.
Rappahannock River oysters; James River (near Newport News, Va.) oysters; Saddlerock oysters; East River oysters.
Oysters from Hampton, Va., 18 months old; from Tangier Sound, Maryland and Virginia.
Oysters from Chincoteague, Va. (first grade); (poorer grade).
Oysters from bottom of scow, Port Royal, S. C., less than 1 year old.
Planted oysters from creeks north of Winyah Bay, S. C.
Oysters from Troups Creek, near Brunswick, Ga.
Raccoon oysters from Cattle Wharf, Charlotte Harbor, Fla.
Oysters from Rocky Point Bed, Tampa Bay, Fla., showing inclusions of mud on inner surface.
Oysters from Catfish Point Oyster Bar, Hillsboro Bay, Fla. (source of supply for Tampa).
Oysters from Little Sarasota Bay, Fla. (a fine grade of oysters, showing inclusions of mud on inner surface).
Oysters from Cape Hayes oyster-bed, Charlotte Harbor, Fla. (important ground, but not much worked until 1888).
Raccoon oysters from mouth of Crooked River, Carrabelle, Fla.
Oysters from Indian Point Bar, Fla. (extra large, showing inclusions of mud on inner surface).
Oysters from Cat Point Bar, Apalachicola Bay, Fla. (showing inclusions of mud on inner surface).
Oysters from St. Mark River, Fla.
Oysters from Cedar Keys, Fla. (average size of those sent to market, showing inclusions of mud on inner surface).
Oysters from St. Vincent, Fla.
Oysters from Watson Bayou, east arm of St. Andrews Bay, Fla.
Oysters from Porter and Sylvia bays, St. George Sound, Fla.
Oysters from Dog Lake, La.
Planted oysters 1 year old, from Escambia Bay, Fla.
Jack Stout oysters, Louisiana.
Oysters from Calcasieu Pass, La.
Oysters from Matagorda Bay, Tex. (average size).
Young oysters from planted beds, Galveston Bay, Tex.
"Saddle-rocks" of Texas, Cedar Bayou, Tex. (125 will often fill a barrel).
Ostrea lurida, growing on shells of *Ostrea virginica* in San Francisco Bay. The native oyster tends to cause much damage in this way.

(4) Mollusks, oyster and other shells—Continued.

Ostrea virginica, natural growth derived from the oysters planted in San Francisco Bay.

Ostrea virginica, transplanted from the Atlantic coast to San Francisco Bay and there raised for market.

Ostrea virginica, Guaymas, west coast of Mexico; used as food.

Ostrea lurida, Pacific coast of the United States; used as food.

Ostrea virginica, Guaymas, Mex., formerly shipped to the San Francisco market.

Ostrea lurida, the native oyster of the Pacific coast of the United States; from Willapa Bay, Wash.

Ostrea lurida, the native oyster of the Pacific coast of the United States; from San Francisco Bay, Cal.

Oyster growing on twig of tree.

Sheet of rubber containing oyster spat.

Rubber shoe with young oyster attached, Connecticut.

Anchor lantern with oysters growing on it.

Earthenware ink bottle with oysters growing on it.

Glass bottle with oysters growing on it.

One-year-old oysters growing on gutta-percha cable across Housatonic River at Stratford, Conn.

Spat about two months old attached to crushed stone off Norwalk, Conn.

Crushed stone, used on planted beds for collecting oyster spat. Recent innovation.

Jingle clutch, used on planted beds for collecting oyster spat; composed of the shells of *Anomia* and other light mollusks, and very highly regarded under some conditions.

Oyster spat growing on child's leather shoe.

Cockle (*Cardium corbis*), Pacific coast of North America; edible.

Horse mussel (*Modiola modiolus*), Greenland to New Jersey, Europe, North Pacific Ocean; used as food and bait.

California mussel (*Mytilus californianus*), Pacific coast of North America; used as food.

(5) Other economic mollusks:

Haliotis, California.

Pearl oyster (*Meleagrina margaritifera*), Gulf of California.

Giant scallop (*Pecten tenuicostatus*), Labrador to New Jersey; used as food.

Common scallop (*Pecten irradians*), Massachusetts to Gulf of Mexico used as food.

(6) Enemies of the oyster:

Starfish attacking oysters. Starfish.

Egg cases of the periwinkles (*Fulgar carica* and *Sycotypus canaliculatus*).

Asterias forbesii and small specimens clustered in shell of periwinkle, off Norwalk, Conn.

Starfish feeding on common mussels (*Mytilus edulis*), Providence, R. I.

Periwinkle (*Sycotypus canaliculatus*), Massachusetts to Gulf of Mexico. Destructive to oysters.

Asterias forbesii. Medium specimen in shell of periwinkle. Connecticut.

Sea snail (*Nererita duplicata*), Massachusetts to Gulf of Mexico.

Drills (*Purpura lapillus*).

Oyster shells showing the effect of the boring-sponge (*Clione sulphurea*), Tangier Sound, Va.

Drills (*Urosalpinx cinerea*), Massachusetts to Gulf of Mexico; also introduced with oysters in San Francisco Bay, Cal.

Razor-clam.

Flat razor-clams (*Machæra patula*), Alaska to California; used as food.

Giant clams (*Schizothærus nuttallii*), Pacific coast of North America; used as food. New England Coast. Arctic Ocean to South Carolina.

Long clam or soft clam (*Mya arenaria*), Eastern United States; also introduced on Pacific coast; used as food and bait.

Large clams.

Quahog or round clam (*Venus mercenaria*), Gulf of St. Lawrence to Gulf of Mexico; used as food and bait.

Clams (*Mactra planulata*), Alaska; used as food.

Sea clam or surf clam (*Mactra solidissima*), Labrador to Gulf of Mexico; used as food and bait.

Bloody clams (*Argina pexata*), Massachusetts to Gulf of Mexico; occasionally used as bait.

Little-neck clams, hard-shell clams, carpet shell (*Tapes staminea*), Alaska to California; extensively used as food.

Little-neck clams (*Saxidomus aratus*); esteemed as food. San Diego, Cal.

Round clams (*Saxidomus nuttallii*), Pacific coast of North America; used as food.

Division of Fish-Culture.

(1) Transportation apparatus: Model of U. S. Fish Commission Car No. 1.
(2) Hatching apparatus:
(*a*) Working models:
One whitefish table 8 feet long, 3 feet wide, and 3 feet high, with 12 McDonald jars for hatching shad eggs.
Two hatching troughs 8 feet long, 12 inches wide, and 8 inches deep, equipped for hatching salmon and trout eggs.
(*b*) Accessories:
One egg scale, two funnels for shad, two siphon bags, two siphon cages, one aquarium, one pan for washing eggs.
(3) Hatching and rearing establishments:
Model of U. S. Fish Commission hatchery at Put-in Bay, Ohio.
(*a*) Illustrations of hatching stations, showing buildings, interior and exterior, methods employed in collecting, hatching, rearing, and distributing fish, fry, and eggs.
U. S. Fish Commission hatching station, Wytheville, Va., 1885. Interior of hatchery. Men at work. View of spring and ponds, looking west. View of ponds, looking south. View of ponds, looking southeast.
Launch towing spawntakers. Stripping shad on fishing float. Packing shad eggs. Shipping fry.
U. S. Fish Commission shad station, Havre de Grace, Md., 1892. Bird's-eye view of station. Superintendent's cottage. Hatching house, looking northeast. Interior of hatching house.
U. S. Fish Commission hatching station, Wytheville, Va. View of station, looking north. View of station, looking south.
(*b*) Floating stations: Steamer *Fish Hawk*.
(4) Methods and results of fish-culture:
Models: One lay figure, illustrating method of taking salmon eggs.
Charts:
(*a*) Giving names and locations of stations and output of each for the fiscal year 1894–95.
(*b*) Showing effect of fish-culture on the shad fishery.
Objects of the fisheries:

Division of Statistics and Methods of the Fisheries.

Cetaceans: Blackfish head (cast). Grampus head (cast). Bottlenose porpoise (cast). Harbor porpoise (cast), young.
Carnivores: Northern fur seals (mounted group). Steller's sea lions (mounted group).
Frogs: Bullfrog (cast). Green frog (cast). Pickerel frog (cast).
Fishes: Casts of 150 species of marine and fresh-water food-fishes.
Drawings and notes: Five swinging screens containing drawings of, and notes on, the important fishes of the Southern States.
Live fishes: Living marine and fresh-water fishes in aquaria.
Invertebrates: Living crabs, mollusks, etc., in aquaria.
Vessels:
Series of models showing the development of fishing vessels from the settlement of America to the present time.
Models of vessels used in the important fisheries of the South Atlantic and Gulf States.
Nets: Three pound nets, one cast net, one whitefish gill net, four fyke nets, one dip net, one aboriginal fish weir, two herring weirs.
Traps and pots: Six eel pots, four lobster pots, one eel trap (model), three fish-cars (models).
Lines: One halibut trawl line, one George's cod hand line, one shore cod hand line, one cod hand line, one shore cod and pollock hand line, one layout line, one sea trout line, one drumfish line, one whiting line, one reef line, one jack trolling line, one kingfish line, one grunt line, one rockfish line, one Italian fishery line, one line with jug floats, one Alaskan halibut line with hook and club.
Appliances for seizing: Two pairs oyster tongs, one pair oyster nippers, one oyster rake, one pair deep-water oyster tongs, three clam hoes, one hand clam hoe, one sponge hook, four codfish jigs, one dolphin drail, twelve bluefish and brass drails, four Eskimo codfish hooks, four British Columbia wooden fish hooks, one series of spring claw or trap hooks, one series of barbless hooks, two shark hooks, one water glass used in sponge fishery.

Appliances for striking: One series of eel spears, two frostfish spears, three crab and flounder spears, one five-pronged grain, one conch harpoon, one turtle peg harpoon, one series of Indian fish spears, one series of swordfish dart heads, two porpoise harpoons, two porpoise lances.

Illustrations of fisheries:

Four pictures illustrating the seal fishery.

One picture of Aleuts killing walrus.

One picture of salmon trap (Indians of Northwest).

One picture of Marsh's improved deep-water oyster tongs.

Thirty-five swinging screens containing views of the different fisheries, U. S. Fish Commission stations, equipments of steamers *Albatross* and *Fish Hawk*, and plates from U. S. Fish Commission Bulletins.

PRACTICAL FISH-CULTURE.

During the months of May and June 3,500,000 shad eggs were received from the Susquehanna, Delaware, and Potomac rivers by express and hatched in apparatus provided for illustrating practical fish-cultural work. Of the fry resulting, 1,400,000 were liberated in the Cumberland River and 215,000 were held until July for exhibit. Besides the black-spotted and rainbow trout eggs from Colorado, received in June, 20,000 eggs of the quinnat salmon were shipped from California during the fall months. These eggs were hatched in water from the artesian well, and the fry were placed on exhibition and planted in suitable waters in the vicinity. This feature of the exhibit was particularly interesting to the people of that section of the country, as it was the first time that the eggs of any of the Salmonidæ had been artificially hatched in Tennessee. This was only rendered possible by the sinking of a well near the Government building, which furnished an excellent flow of water at 59° throughout the summer.

THE AQUARIUM.

The aquarium was a grotto-like, L-shaped structure, 120 feet long and 28 feet wide, containing 22 tanks, arranged in equal numbers on each side of the passageway 12 feet wide. Each tank was 7 feet long, 3 feet high, and 5 feet wide at the top, with a capacity of 55 gallons. The tanks next to the wall were arranged for the exhibition of the various fresh-water species; those upon the opposite side were placed for the exhibition of salt-water species, which included snappers, groupers, pompano, crevalle, mullet, and other bright-colored tropical fishes, as well as the crustaceans, shellfish, etc.

The water for the fresh-water aquaria was obtained from a well 84 feet deep located near the southeast corner of the building, which permitted the exhibition of a number of specimens of rainbow and brook trout and steelhead trout throughout the exposition.

The water in the salt-water tanks was brought from Morehead City, N. C., in tank cars, and stored in a large reservoir beneath the floor; from this it was forced by means of nickel pumps, driven by electricity, into a smaller tank located 18 feet above the floor, whence it passed by gravity to the aquarium, thence returning to the reservoir.

The interior of the grotto was lighted through the aquarium tanks and a number of ventilators, placed in the crown of the grotto arch. It was finished in adamant and cement, partly as stuccowork, partly

plastered in imitation of a roughly blasted tunnel. Where the two arms of the L met, a rotunda was formed, with a pool at the bottom of the rockwork, in imitation of the entrance to a water cave, which was illuminated by electric lights. Here and there in the grotto, masses of ferns and other evergreens were planted in the rockwork. Two arched portals, in imitation of cut stone, and of simple architectural design, formed the entrance to the grotto. The pool in the rotunda referred to was one of the most attractive features of the aquarium, being filled with bright-colored fishes, and lighted with electric lights, submerged in water. It also contained a large sturgeon, about 5 feet long, which was an endless source of amusement and interest to the visiting public.

The plans for the aquarium were prepared by Mr. G. A. Schneider, who was in charge of its construction and installation.

FISHES IN THE AQUARIUM.

Collections of salt-water fishes were made at Morehead City, N. C., and at Pensacola, Fla., under the direction of Mr. L. G. Harron, the superintendent of the aquarium. The fresh-water fishes were chiefly obtained from the Fish Commission stations at Wytheville, Va., and Quincy, Ill., and the fish-ponds in Washington, though collections of fishes native to that section were made from time to time in the immediate vicinity of Nashville.

During the summer much difficulty was experienced in keeping up the display of fishes on account of the intense heat prevailing at that time. In June the temperature of the water rose rapidly, and when it reached 78° it became necessary to resort to artificial means to save the fish, notwithstanding that the specimens on exhibition were all collected in southern waters. This was accomplished by passing the water through 300 feet of iron pipe arranged in the shape of a coil and packed in crushed ice and salt.

By this means the temperature of the water was kept down below 70°, but the method proved very expensive, as it required over 1½ tons of ice per day. Later in the season the water from the well was used for cooling the salt water after it had passed through the trough and tanks containing salmon eggs and salmon.

FISH FOOD.

Round beefsteak was mainly used for food, although the diet was varied by the use of beef liver, live minnows, clams, and fiddler-crabs. The latter were shipped by express from Pensacola, packed in sand. In the preparation of the beef and liver the fat and sinews were carefully removed, and it was then cut in sizes to suit the fish. For the small specimens it was ground fine in a meat-chopper; for the larger, in pieces varying in size. In feeding the marine fishes with beef or liver a small amount of table salt was added. The black bass and crappie, which were the most difficult to keep, were fed entirely on minnows.

FISHES EXHIBITED.

During the exposition over 9,672 fishes and other animals were shown in the aquarium, of the following species:

Marine species.	Marine species.	Fresh-water species.	Fresh-water species.
Red snapper.	Cavally.	Goldfish.	Black bass, large mouth.
Black snapper.	Squirrel-fish.	Golden ide.	Black bass, small mouth.
Mullet.	Stingray.	Quinnat salmon, fry.	Black bass, fingerling.
Sheepshead.	Soapfish.	Quinnat salmon.	Warmouth bass.
Burfish.	Gaff-topsail.	Steelhead trout.	Crappie.
Swellfish.	Pompano.	Rainbow trout, fry.	White bass.
Sea-urchin.	Flounders.	Rainbow trout, adults.	Striped bass.
Sea-robin.	Spot.	Brook trout.	Yellow bass.
Sea bass.	Catfish.	Yellow perch.	Sunfish.
Sea-horse.	Sea trout or spotted squeteague.	White perch.	Rock bass.
Cowfish.		Pike.	Catfish.
Hogfish.	Red drum.	Suckers.	Tench, green.
Pigfish.	Look-down.	Chubs.	Carp.
Sailor's choice.	Hermit-crab.	Garfish.	Tench, golden.
Croaker.	Blue-crab.	Eels.	Buffalo-fish.
Red grouper.	Spider-crab.	Sturgeon.	Minnows.
Black grouper.	Horseshoe-crab.	Dogfish.	Turtles.
Toadfish.	King-crab.	Redhorse.	
Spadefish.	Fiddler-crab.		
Filefish.	Clams.		
Pompano.	Conch.		
Bluefish.			

During the absence of the representative from Nashville, the exhibit was, at different times, under the direction of Mr. L. G. Harron, Mr. W. P. Sauerhoff, and Mr. R. J. Conway. Mr. Conway was in charge at the close of the exposition, and attended to the packing and shipping of the exhibits to Washington and Omaha during the months of November and December.

ACKNOWLEDGMENTS.

The Commission is indebted to the Secretary of the Smithsonian Institution for the loan of material and cases forming part of the exhibit.

Acknowledgments are also due to—

The Union Tank Line Company, of New York, for the loan of tank cars for the transportation of salt water;

The Chesapeake and Ohio Railroad, the Louisville and Nashville Railroad, and the Nashville, Chattanooga and St. Louis Railroad for the free transportation of tank cars containing salt water and the transportation of the Fish Commission cars and messengers engaged in the collection of fishes for the aquarium;

The Exposition Company for assistance rendered in the installation of the electrical appliances and the free use of power;

The Laidlaw-Dunn-Gordon Company, of Cincinnati, for the loan of an electric pump used in the circulation of fresh water;

Mr. C. W. Hicht, for the free use of water from the Cockwell spring.

Assistance was also rendered by Mr. Robert T. Creighton, the engineer of the Exposition Company; Mr. C. H. Pendacost, superintendent of electricity; and Mr. William Reyer, superintendent of the Nashville, Chattanooga and St. Louis railway shops.

EXPENDITURES.

The total cost of the preparation, maintenance, and return of the exhibit of the Commission, including the aquarium, was $16,290.61.

The following statement shows the objects for which the money was expended :

Services	$2, 131. 91
Special or contract services	2, 325. 75
Travel	1, 117. 74
Subsistence	2, 261. 10
Freight	366. 34
Cartage	54. 97
Expressage	270. 41
Exhibition cases, frames, etc	3, 190. 25
Lumber and millwork	73. 29
Hardware, tools, etc	95. 90
Glass, paints, brushes, etc	691. 15
Supplies and preparator's materials	1, 893. 82
Packing material	23. 71
Apparatus, specimens, etc	1, 131. 58
Decorations, partitions, etc	407. 30
Office expenses	255. 36
Total	16, 290. 61

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